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CONTRIBUTORS

Dr. Eli Ginzberg ("The Economics of British Neutrality during the American Civil War") is lecturer in business administration at Columbia University. He is a graduate of Columbia University (B.A., M.A., Ph.D.) and has studied at Heidelberg University and the University of Grenoble. Among his published works are *Studies in the Economics of the Bible* (Philadelphia, 1932), *The House of Adam Smith* (New York, 1934), and *The Illusion of Economic Stability* (in press).

Dr. Russell H. Anderson ("Grain Drills through Thirty-Nine Centuries") is curator of agriculture, textiles and forestry at the Museum of Science and Industry founded by Julius Rosenwald in Chicago. In addition to research incident to the work of the Museum, he is making an extensive study of the development of agriculture in Illinois. His writings include "New York Agriculture Meets the West, 1830–1850," in *Wisconsin Magazine of History*, 16:163–198, 285–296 (December 1932, March 1933), and "The Technical Ancestry of Grain-Milling Devices," in *Mechanical Engineering*, 57:611–617 (October 1935).

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THE ECONOMICS OF BRITISH NEUTRALITY DURING THE AMERICAN CIVIL WAR[1]

History, like the other social studies, is subject to powerful fashions. Factors once completely ignored may suddenly be overemphasized. Criticism presages the eclipse of prevailing theories, and research the emergence of the novel. Such is the dynamics of scholarship. In the past, the economic interpretation of history was wantonly neglected; at present, it is in its heyday; tomorrow its star will probably shine more dimly.

Professor Louis Bernard Schmidt, in a paper presented at a session of the American Historical Association, meeting at Philadelphia in 1917, examined the economics of British neutrality during the American Civil War, especially the data relating to the major staples of the contestants, namely, wheat and cotton.[2] His study was in part precipitated by the increased interest in international relations incident to the entrance of the United States into the World War. Professor Schmidt observed that the influence of wheat "seems to have been consistently overlooked by all students of Anglo-American relations" during the Civil War and concluded that "Northern wheat . . . may well be regarded as the decisive factor, counterbalancing the influence of cotton, in keeping the British government from recognizing the Confederacy." So impressive was the evidence presented in

[1] The basic draft of the present article was completed several years ago. The author is indebted to Professor Harry J. Carman of Columbia University for having called his attention to the subject as one worthy of investigation and to Everett E. Edwards of the U. S. Department of Agriculture for valuable assistance in preparing the manuscript for publication.

[2] L. B. Schmidt, "The Influence of Wheat and Cotton on Anglo-American Relations during the Civil War," in *Iowa Journal of History and Politics*, 16:400–439 (July 1918). The article is reprinted with omissions in L. B. Schmidt and E. D. Ross, editors, *Readings in the Economic History of American Agriculture*, 304–321 (New York, 1925). The original version has been used in the preparation of the present article, and all quotations and data not otherwise documented are from this source.

support of this wheat vs. cotton thesis that a considerable number of American historians appear to have accepted it.[3] Although criticism and skepticism have not been completely absent, they have been infrequent and inconclusive. As late as 1932, a specialist wrote that "Probably more evidence than has yet been collected is needed to settle this point."[4]

The present reëxamination of the economics of British neutrality during the American Civil War includes an analysis of the data originally presented in substantiation of the wheat thesis as well as an evaluation of the criticisms levied against it. Study of the thesis and these criticisms should throw light on the broader problem of historical method, especially on the interrelation of theories and facts.

The evidence presented to show that wheat from the northern and western sections of the United States was a factor of major importance in committing British foreign policy to neutrality may be subsumed under four heads:

1. Great Britain had become a great wheat-importing country by 1860. During the preceding five years, it consumed an average of 21,000,000 quarters per annum, of which 16,000,000 were produced at home. Hence, it imported between 25 and 30 percent of its annual supply. During the years 1860–62, the harvests were exceedingly poor and its annual production averaged only 12,000,000 quarters, thus necessitating a doubling of imports if consumption were not to be curtailed.

2. Russia, Prussia, France, and the United States were Britain's principal sources of supply. In 1861 and 1862, France suffered severe crop failures and was forced to curtail its exports of grain. The English imports from Russia and Prussia remained steady

[3] J. T. Adams, *The March of Democracy*, 2:20–22, 82 (New York, 1932); C. A. Beard and M. R. Beard, *The Rise of American Civilization*, 2:82, 84 (New York, 1927); H. U. Faulkner, *American Economic History*, 391–394 (New York, 1929); and William Trimble, "Historical Aspects of the Surplus Food Production of the United States, 1862–1902," in American Historical Association, *Annual Report* (1918), 1:224 (Washington, 1921). Cf. Edward Channing, *A History of the United States*, 6:340–341 (New York, 1925), and E. D. Fite, *Social and Industrial Conditions in the North during the Civil War*, 1–2, 17 (New York, 1910).

[4] M. B. Hammond, in *American Economic Review*, 22:704 (December 1932).

during the war years; these countries "were unable to respond to Great Britain's greatly increased demands."

3. In 1860, the United States was an important wheat-producing country. The outbreak of hostilities cut off the Southern market for Northern wheat, thereby releasing supplies for England in this hour of need. The United States exported 2.1 million quarters to the United Kingdom in 1860, 3.6 million in 1861, and 5.0 million in 1862. At a time when imports were mounting rapidly, the United States supplied an ever larger percentage of the total—11.2 percent in 1858–59; 29.2 percent in 1860; 41.5 percent in 1861; 43.5 percent in 1862; and 38.4 percent in 1863.

4. Speeches in Parliament and articles in periodicals during the war show that English public opinion was conscious of the dependence of the British Isles on American wheat, a dependence well recognized by those who formulated British foreign policy.

The late Professor Ephraim Douglass Adams, a leading authority on Anglo-American relations during the Civil War, did not accept the view that the need of American wheat was a factor determining British neutrality.[5] He disposed of the wheat thesis on three counts: 1, By midsummer of 1863, British intervention was no longer a real threat; the danger had passed by January of that year; 2, It is a mistake to equate cotton and wheat for "the former could not be obtained in quantity from *any* source before 1864" but increased imports of the latter were solely a matter of price; 3, The Governmental memoranda are absolutely silent on the question of wheat.

The thesis is damaged but not demolished by the fact that a majority of the references to wheat in Parliament date from the Roebuck Resolution of June 1863, at which time intervention was already a forlorn hope. British dependence on grain from the American Middle West had previously been discussed in the House of Commons, and the argument was known and respected, at least by a few if not by many.[6] Furthermore, Professor

[5] E. D. Adams, *Great Britain and the American Civil War*, 2:13, footnote 2 (New York, 1925).

[6] *Ibid.*; Schmidt, 436–437; F. L. Owsley, *King Cotton Diplomacy; Foreign Relations of the Confederate States of America*, 450–488 (Chicago, 1931).

Adams's contrast between the absolute inelasticity of the supply of cotton and the relative elasticity in the supply of wheat is not well supported by factual evidence. With the drastic decline in the cotton imports from the United States, there occurred a steady and progressive increase in imports from other countries.[7]

Year	*United States*	*Other Countries*
1860	2,580,700 bales	785,000 bales
1861	1,841,600 "	1,194,000 "
1862	72,000 "	1,445,000 "
1863	132,000 "	1,932,000 "
1864	198,000 "	2,587,000 "
1865	462,000 "	2,755,000 "

In the light of Professor Adams's intimate acquaintance with the British state papers, his third criticism, which he believed to be "conclusive in negation" of the thesis, is highly significant.

In discussing "the influence of wheat in keeping John Bull on his good behavior with the United States" Professor Frank Lawrence Owsley, in his book on *King Cotton Diplomacy*, places himself at the forefront of the critics of the thesis.[8] He holds, however, that the "complete silence on the subject . . . in the cabinet circles. . . . would not be conclusive were there not other evidence of a more positive character which corroborates this negative evidence." His position may be summarized thus: 1, The "wheat famine" idea can be traced from John Bright and William E. Forster back to Charles Francis Adams and thence back to William H. Seward and Abraham Lincoln; in short, it was a piece of Federal propaganda. 2, The British press commented on the idea from time to time, but almost without exception sneered at it. The large importations from the United States were a matter of price, not of necessity. 3, "Most important of all . . . England took this wheat in payment for the countless millions of dollars'

[7] Schmidt, 416–420. He points out that the British need for cotton was further modified by the spinning of finer fabrics and by the expansion of the woolen and linen trades which helped materially in taking up the slack due to the depression in cotton. F. L. Owsley, *King Cotton Diplomacy*, 572.

[8] *Ibid.*, 567–568. Owsley's interpretation of British neutrality is based largely on the economics of war profits. The evidence presented (569ff.) is impressive. His interest in the subject, like Schmidt's, was due to reflections on the World War.

worth of rifles, cannon, powder, and other munitions of war which she was selling the United States . . . in 1864 and 1865, after the United States became practically self-sufficient in the production of war supplies and no longer made large purchases from England, the latter country turned abruptly away from America to Russia and East Europe for her wheat supply." Professor Owsley concludes that all the evidence tends "to demonstrate that wheat had little if anything to do with preventing English intervention in the American Civil War."

The famine bogy may have been Federal propaganda, and the wheat exports from the North probably helped to pay for much-needed imports of munitions; yet, if England were truly dependent on American wheat and if informed and influential groups really believed in this dependence, the arguments relating to propaganda and balance of trade are beside the point. The wheat thesis, as originally presented, includes a careful review of the relevant statistics and an analysis of the allusions to dependence on American wheat in the press and the debates in Parliament. Professors Adams and Owsley have contributed greatly to our understanding of the economics of British neutrality, but neither reviewed the basic data offered in support of the wheat thesis. To these we now turn.

At the time of the American Civil War, Great Britain imported from 25 to 50 percent of its annual supply of wheat, and the United States contributed from 30 to 45 percent of this importation.[9] Yet, these figures do not in themselves establish the *strategic* importance of American wheat. It was strategic only if other countries could not meet the demand, and only if the statesof Britain were cognizant of this fact and acted accordingly.

The crop failures of the early sixties affected not only England but also France which in normal years was an important source of

[9] The statistics used in the original version of the wheat vs. cotton thesis as well as in the present article are drawn primarily from two excellent articles: J. B. Lawes and J. H. Gilbert, "On the Home Produce, Imports, and Consumption of Wheat," in the Royal Agricultural Society, *Journal* (ser. 2), 4:359–396 (London, 1868); and H. Evershed, "Variation in the Price and Supply of Wheat," in *Ibid.*, 5:153–262 (London, 1869). Hereafter, these articles are cited as Lawes and Gilbert, and Evershed. There are eight bushels in a quarter.

supply for English imports. For the years 1858 and 1859, France supplied England with over 1.5 million quarters of wheat and flour, or 35 percent of the total imported. During the crucial years, 1860–1862, French exports dropped to an average of less than 600,000 quarters.[10] These data show that France failed John Bull at a crucial time.

What of the other sources of wheat? In 1858 and 1859, England annually received approximately 700,000 and 750,000 quarters from Prussia and Russia respectively. The corresponding figure for the three following years is an average annual import of over 1.2 million quarters for each of these countries. The supply from these countries was assuredly elastic; it increased 70 percent within three years. The statistical data relating to imports from "Other Countries" show an annual average of slightly less than one million quarters for 1858 and 1859—an increase of 100 percent for the following three years.[11] The data relating to the wheat exported from the United States are much more erratic: 1,099,000 quarters in 1858; 99,000 in 1859; 2,143,000 in 1860; 3,602,000 in 1861; and 5,022,000 in 1862,—the annual average for the last three years being 3.6 million.[12] When England needed to increase substantially its imports, all of its major sources of supply, with the exception of France, were able to respond, and the United States most easily. To understand the significance of the American response, the question must be asked: What would have been the predicament of Great Britain if Northern wheat had been withheld?

In 1858–60 there was available annually 5.0 bushels of wheat per capita for the population of the United Kingdom, and the average price was 5s. 10d. The corresponding average for 1860, 1861, and 1862 was 5.7 bushels, and the price approximately 6s. 9d. If Great Britain had not imported a single quarter of

[10] Evershed, 196. The year 1860 is included because of the significance of surplus stocks. Schmidt also included it. The data relate to the United Kingdom.

[11] Evershed, 196. Cf. Schmidt, 426, which reads: "these two countries were unable to respond."

[12] Evershed, 196. The decline was likewise rapid: 2,739,000 in 1863; 2,325,000 in 1864; 945,000 in 1865; 227,000 in 1866.

wheat from the United States during the critical years, the supply would have permitted the per capita consumption to remain at the same level as in 1858–60. That the price would have risen is beyond dispute, but it probably would not have approached the high level of 1854 when wheat sold for more than 10s. per bushel.[13] In this connection, it is important to recall that the exportation of wheat from the Continent depended "on the temptation to sell. A sudden rise on our markets has a singular effect in wringing wheat out of poor countries."[14] As we have already seen, there was wheat to be wrung.

The analysis of the statistical data casts the most serious doubt on the contention that Northern wheat was of strategic importance for Great Britain during the early 1860s. It suggests that the comparatively low price of wheat and flour was the result of ample stocks available in the United States. The wheat thesis would, therefore, retain part of its validity if it could be proven that English statesmen emphasized the significance of American exports. Despite the statistics, it would remain practically intact if it could be proven that this overemphasis helped to shape the policy of British neutrality. Such a claim was originally made by Professor Schmidt and denials were entered by Professor Adams and Professor Owsley. What is the evidence?

The original statement of the wheat thesis frequently cited the *Economist* and the Parliamentary Debates to substantiate the claim that informed opinion was fully cognizant of the importance of Northern wheat for the British Isles and that the responsible members of the Government acted in the light of this consciousness. Throughout the two or more years when British intervention was a live issue, the *Economist*, though opposed to any overt recognition of the Confederacy, failed to advance the wheat argument, although so doing would doubtless have strengthened its advocacy of non-interference. In fact, it devoted remarkably little space to the grain trade in any of its manifold aspects,—a truly unusual fact when we recall the poor harvests of 1860 and 1861. Early in 1862, it included a series of letters that discussed

[13] Lawes and Gilbert, 361, 392, 396.

[14] Evershed, 158.

whether or not the grain shortage was acute.[15] Toward the end of the year, it printed a long and informed article on important phases of the contemporary wheat trade, especially its relation to the English corn grower, the merchant importer, the money market, and the welfare of the masses.[16] The author made no reference to Northern wheat, nor did he express anxiety over Britain's dependence on imports. In short, this well-informed journal did not comprehend the strategic importance of Northern wheat.

A review of the Parliamentary Debates is not quite so barren of results. On July 18, 1862, William S. Lindsay, in urging his motion for British mediation, read a letter from America which contained the following:[17]

> Is she [England] afraid for her Northern supplies of bread stuffs? Let her consider that her demand for them is the lifeblood of our agricultural States. They must sell to her. The probable loss of her custom alone would secure her from any danger on our part.

Speaking on the same motion, W. E. Forster pointed out: "We had a cotton famine now; but if we did that [intervened], we should stand in danger of a corn famine."[18] In the course of the same debate, Seymour Fitzgerald contrasted these two famines:[19]

> A cotton famine was not like a corn famine. When the potato crop failed one year in Ireland or the wheat crop in England, there was always the prospect and the hope that in the year following the kindly fruits of the earth would be enjoyed in due season. But it was not so with the cotton crop.

Lindsay was an avowed agitator for the South, and Forster for the North. The wheat argument as presented by the former was expounded in a letter from a Northerner propagandizing for the cessation of hostilities. Forster, an equally rabid partisan for the Union, placed little emphasis on wheat. Fitzgerald refused to be impressed, though he considered it worthwhile to point out

[15] *Economist* (London), 20:33, 61, 90–91, 145 (Jan. 11, 18, 25, Feb. 8, 1862).

[16] *Ibid.*, 20:1173–1180 (Oct. 25, 1862). Its discussion of the relation of the grain trade to the money market supports Owsley's explanation of the large exports of American wheat.

[17] *Hansard's Parliamentary Debates* (ser. 3), 168:521.

[18] *Ibid.*, 536.

[19] *Ibid.*, 575.

the grounds for his skepticism. Viscount Palmerston spoke for the Government, and though his speech was in accord with the best tradition of English diplomacy—platitudinous, sonorous, and obscure—it did not contain the slightest reference to wheat.

About a year later when the Roebuck Resolution was before the House of Commons, Lord Robert Montagu referred to the wheat argument while speaking against mediation. He held that the distress in England would doubtless be aggravated if the Northern States ceased to export grain. What is more important, he asserted that such a cessation would lead to a substantial impairment of the economic and political relations then existing between the Middle West and Canada, as Northern grain frequently, and in large quantity, passed through Canada.[20] In the course of the debate, Forster returned to the wheat argument: "... unless the harvest were better than it promised, the sufferings of the countrymen of the hon. Member [Mr. Maguire] would be great indeed if they were deprived of the American corn crop of this year."[21] Montagu emphasized the lucrativeness of Canadian trade and pointed out that war with the North might lead to the loss of those important colonies. Even Forster was not eschatological, and John Bright, who also joined in the debate, failed to mention the wheat argument.[22]

The members of Parliament were not completely ignorant of the rôle that Northern wheat was playing, and more important, might play if Britain failed to remain neutral. It is, however, extremely doubtful that a small minority, not to mention a responsible majority, considered this rôle important, much less strategic. The argument was most respected by agitators, but even they failed to consider it worthy of more than passing comment.[23]

The review of the statistical data suggests that the figures by themselves do little to support the wheat thesis. Likewise, the literary data do not withstand careful scrutiny and therefore fail to supply the necessary substantiation. Thus ends a cycle.

[20] *Ibid.*, 171:1795.
[21] *Ibid.*, 1813.
[22] *Ibid.*, 1826–1838.
[23] Cf. Owsley's discussion of the genesis of the thesis.

A historical factor "consistently overlooked by all students" is finally discovered; then others acknowledge it, although a few remain skeptical. Slowly their skepticism is transformed into criticism, and eventually the discovery must give way.

Historians frequently fail to realize that the economic interpretation of history is impossible,—that economic interpretations are as manifold as economic factors.[24] Furthermore, interpretations must differ with the length of the cross-section. An economic factor may be of strategic importance in explaining broad movements—the Decline of Rome, the Rise of the British Empire, the Abolition of Slavery in the United States—but it cannot be relied on primarily, not to mention solely, in analyzing the outbreak of a war, or the neutrality of an interested party. To do so is clearly fallacious. Factors other than economic are most frequently catalytics. Man individual differs from man collective, and history is concerned with man collective. It is indeed doubtful whether rational calculation explains much of individual behavior; clearly it explains almost nothing of the behavior of groups.

ELI GINZBERG

School of Business,
Columbia University.

[24] Cf. V. G. Simkhovitch, *Marxism vs. Socialism, passim* (New York, 1913), and "Approaches to History," in *Political Science Quarterly*, 44:481–497; 45:481–526; 47:410–439; 48:23–61; 49:44–83; 51:117–151 (1929ff.).

GRAIN DRILLS THROUGH THIRTY-NINE CENTURIES[1]

Millet's celebrated painting, "The Sower," has immortalized the farmer at one of his major tasks. From time untold he has scattered by hand the seed from which he raised his bread. This method of seeding is well known and needs no further description. We are here concerned with the effort of man through thirty-nine centuries and over a range of territory from Babylonia to America to devise a mechanical means of eliminating this hand operation. It was to relieve man of the burden of hand labor and to secure a better crop that attempts were made to produce a grain drill. It was difficult to sow evenly by hand, and it was necessary to cover the seed by a separate operation. Not only did this entail extra work but it was not easy to cover the seed deep enough to secure protection against drought and freezing.[2]

It seems evident that man sought to overcome the defects of hand seeding by making a hole in the ground with a sharpened stick, dropping the seed in, and covering it with his foot. Even now primitive tribes throughout the world use this device, known as a dibbling stick, and have, no doubt, done so for ages. Vergil tells how the Romans set their grain seed with their fingers with the possible assistance of a dibbling stick. Even in Europe and America the device is now used to some extent in gardens.[3]

[1] An address read before the joint meeting of the Agricultural History Society and the American Historical Association at Chattanooga, Tennessee, on Dec. 27, 1935.

This study is limited almost entirely to grain drills. Except where common elements or parallel developments seemed to justify mention of them, it has not been practicable to include broadcast seeders of any kind, turnip or beet drills, corn or cotton planters, etc. Consideration of these machines, together with a more thorough discussion of grain drilling, might properly be included in a comprehensive study of seeding.

[2] For illustrations showing Egyptians sowing by hand, see N. de G. Davies, *The Tomb of Nakht at Thebes*, pls. 6, 18, and 21 (New York, 1917), and Hugo Gressman, *Altorientalische Bilden zum Alten Testament*, pl. 73 (Ed. 2. Berlin, 1927).

[3] For example, the non-Christian tribes of the Philippine Islands use a dibbling stick to plant their upland rice.

Before passing to more significant developments, let us follow briefly the story of seeding with dibbling devices. In 1600, Sir Hugh Platt, in his book, *Adam's Tool Revived*, described the advantages of "setting corn" over sowing broadcast and recommended making holes three inches deep and three inches apart to receive the grain. The dibbling frame that he described consisted of pegs set in a board and was an attempt to apply quantity methods to this simple and limited device. Incidentally he advised filling the holes with good compost.

Sometime later Gabriel Plattes described a very complicated dibbling drill or "engine" which consisted of a sliding seed-dropper and a row of metal pins which moved up and down within metal seed-funnels and made the holes for the seed. A second proposal covered two separate machines, one for making holes and the other for dropping seed.

In 1670 Father Francesco Lana-Terzi, a Jesuit of Brescia in Lombardy, designed a dibbling-type seeding-machine which was also tried in England and the Germanies. It consisted of a frame having spikes which made holes for the grain and guide holes at the corners. A second part of this device was a dropping frame with corner guide spikes. Seeds were dropped through holes in the frame so spaced as to correspond to the holes in the soil below. This seeder had the same limitations inherent in all dibbling devices and came to nothing.[4]

[4] John Worlidge, *Systema Agriculturae*, 43–45 (London, 1675), cited Sir Hugh Platt's method of using a dibbling frame which he says was new in 1600 and quoted the description of the dibbling engines from Gabriel Plattes, *A Discovery of Infinite Treasure* (London, 1639). J. C. Loudon, *An Encyclopaedia of Agriculture*, 364 (London, 1825), described the common dibbler in use in England as having several teeth or dibbles proceeding from a head to which a handle was attached and mentioned that the common garden dibbler was often used in heavy clay soils. The illustration in *British Husbandry*, 2:83 (London, 1841), shows the common dibbler with one point.

The invention of Father Lana-Terzi of Brescia was described in Johann Beckmann, *Beytraege zur Geschichte der Erfindungen*, 4:390 (Leipzig, 1797), which cites *Prodromo, ouero saggio di alcune inuentioni nuove, premesso all' arte maestra*, 96, fig. 26 (Brescia, 1670). It is also mentioned in J. G. Kruenitz, *Oekonomische-Technologische Encyklopaedie*, 129:488 (Berlin, 1821). Charles Varlo, *A New System of Husbandry*, 1:ch. 26–27 (Winchester, 1774), advocated sowing by a dibbling frame and transplanting. See J. C. Morton, ed., *A Cyclopedia of Agriculture*, 2:903–906 (Glasgow, 1855), for an account of the English dibblers.

So far as is now known, the earliest fabricated grain drill was that represented on a Babylonian seal cylinder found at Tell Asmar and which appears to date from about 2000 B.C. The figure is crowded and highly generalized and the details of the drill are not entirely clear, but there seems to be no doubt about its general features. In construction it is very similar to the Babylonian plow of the period. Like the plow it has no mold-board but consists of a plow-stock, two handles and a pole braced by an upright member from the plow-stock. The construction of this brace appears to be almost identical with that on the plow,

FIG. 1. Babylonian grain drill. A highly generalized representation from an impression of a seal cylinder found at Tell Asmar, dating from about 2000 B.C., to be interpreted in the light of the distorted drawing of that period. Courtesy of the Oriental Institute, University of Chicago.

which antedates it some 500 years, but in this instance there is shown the figure of a man who is evidently dropping grain into the top of the brace which seems to serve as a seed-pipe. There is a distinct similarity between the action of this man and that of one of the operators of the Kassite seeder mentioned below, (see fig. 3) about which there can be no doubt. In this case there are distinct indications of furrows. Possibly this drill was not widely used. It is significant, however, not merely because it is an example of the adaptation of an old tool to new uses, but largely because it contained two of the three essential elements of a successful grain drill, namely, the drill shoe and the seed-pipe. The

third element, the revolving seed-dropping device was, apparently, not added until some thirty-six hundred years later.[5]

When we reach the Kassite period of Babylonian history we are on somewhat surer ground. An improved grain drill is shown

FIG. 2. Babylonian grain-drill model in the collections of the Museum of Science and Industry, Chicago, based on Fig. 3.

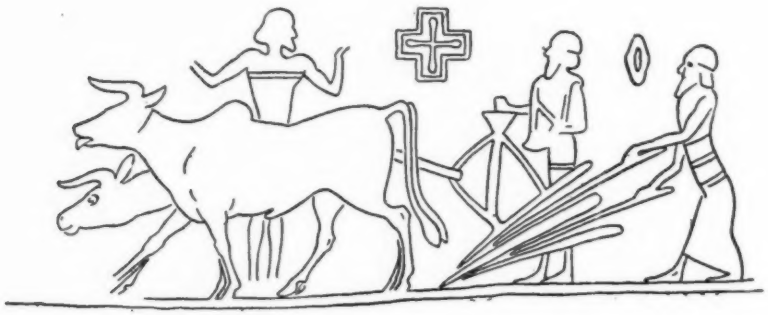

FIG. 3. Babylonian grain drill, 1316 B.C. Courtesy of the University Museum, University of Pennsylvania.

on a clay tablet dating from 1316 B.C., the fourth year of the reign of Nazi-Maruttash II. This drill is similar in general to the early Babylonian plow and the Tell Asmar drill described above except in the addition of improved bracing and two ears

[5] Henri Frankfort, *Tell Asmar, Khafaje and Khorsabad; Second Preliminary Report of the Iraq Expedition*, p. 46 and fig. 27, as. 31–660 (Oriental Institute Communications 16. Chicago, 1933), and members of the staff of the Oriental Institute of the University of Chicago.

which formed rudimentary moldboards and assisted in opening the furrow in the comparatively soft earth. It had two handles and a drill shoe in the form of a stick plow-point. Rising vertically from the drill shoe, about one-third of the distance from the point, was a seed-tube which ended at the top in a funnel into which the seeds were dropped. This seed-pipe was braced to the upper part of the slanting drill shoe by a tough tree branch properly bound. Another branch bent in a V-shape was fastened in front of the seed-pipe at the top and bottom to take the pull of the oxen through a pole loosely attached at the knee of the brace. The yoke, fastened to the horns of the cattle, was attached to this pole. Whatever may have been its virtues in placing the seed in the ground properly, its limitations are evident when one considers that three men were required to operate it,—one to drive the oxen, one to put the grain in the hopper as the drill proceeded, and a third to hold the drill steady. This crew with two oxen could scarcely drill an acre a day. Contrast this with the work of one man today who may drive a tractor pulling six drills covering 80 feet and seeding 400 acres in ten hours.[6]

In the seventh century B.C., the Assyrians used a modification of the Babylonian drill but with no essential additions. The drill shoe entered the ground at a smaller angle than in the case of the

[6] The clay tablet depicting this Babylonian drill is in the Archaeological Museum of the University of Pennsylvania. The date, 1316 B.C., is commonly accepted as correct. The figure is reproduced in A. T. Clay, *Documents from the Temple Archives of Nippur Dated in the Reigns of Cassite Rulers*, 2 (2):66 (Philadelphia, 1912), and in Hugo Gressman, *Altorientalische Bilden zum Alten Testament*, p. 53, pl. 72, fig. 161 (1927). This drill is shown in F. M. Feldhaus, *Die Technik der Antike und des Mittelalters*, 93, fig. 115 (Wildpark-Potsdam, 1931), but the date is erroneously given as about 500 B.C. The Bibliotheque Nationale has a Babylonian seal cylinder portraying a very crude implement similar to the Babylonian drill described above except that it does not have the ears. The seed tube is indistinct and the construction is very weak. It is difficult to date this cylinder. See Félix Lajard, [Atlas] *Introduction à l'Étude du Culte Public et des Mystères de Mithra en Orient et en Occident*, p. 9 and pl. 34, no. 15 (Paris, 1847).

Although references are frequently found to the reputed antiquity of the grain drill in India, China, and Japan, the writer has not seen sufficient evidence to justify his making definite statements. See Loudon, *Encyclopaedia of Agriculture*, 386, who cites a statement in Walter Harte, *Essays on Husbandry* (London, 1764), that the first grain drill was invented by a German and presented at the Spanish court in 1647. This may be an erroneous reference to the Locatelli trial.

earlier drill and the pole was attached to the base of the seed pipe and by a brace at the top. From all we can determine it lacked ears like those found on the Babylonian drill.[7]

Little or nothing seems to have been accomplished toward perfecting a mechanical grain drill from the fourteenth century B.C. to the sixteenth century of our era. In 1566 the Venetian Senate granted to Camillo Tarello of Lonato a "patent" for a system of sowing grain which was much commended for saving seed and increasing the yield. It may be supposed, although it is not clear, that the improvement of Tarello consisted in part of an improved grain drill but, if so, the details are lacking.[8]

[7] See the "Inscription Stone of Asharhaddan, 680–669 B.C.," in Hugo Gressmann, *Altorientalische Bilden zum Alten Testament*, p. 53, fig. 163 (1927). J. T. Allen, *Digest of Seeding Machines and Implements Patented in the United States, . . . 1800 . . . to . . . 1878*, p. [iv] (Washington, D. C., 1879) reproduces a drawing which seems to have been taken in the first instance from the inscription stone although he supplies no reference and gives a very inaccurate account of the Assyrian, Cavalini, and Locatelli drills. He erred in having the drill shoe horizontal and in dating it at 504 B.C. Benjamin Butterworth, *Growth of Industrial Art*, 6 (Washington, 1888), reproduced this incorrect drawing and date. The same errors are made in the following: W. L. Braley, "4730 Years of Grain Drill History," in *Hardware and Implement Journal*, 35 (4):25–27 (April 1930), *Oliver Shield*, Apr. 1, 1930, p. 6–7, *Canadian Implement Trade Journal*, March 1930, p. 6–8, and *Farm Implement News*, 51(18):30–31 (May 1, 1930).

[8] For a modern account of the work of Tarello and Cavalini, see Lino Sighinolfi, *Taddeo Cavallini, Inventore Della Prima Seminatrice per Cereali* (1930). This memoir also appears in the Agricultural Society of Bologna, *Annals* (1928–29):295–311. There are no illustrations in either case, and so far as is known none have ever been found. Sighinolfi quotes the patent application—in which, unfortunately, no description of the drill appears—in which the name is given as Tadeo Cavalini. Sighinolfi gives a description of the drill taken from P. Gio Battista Segni, *La Carestia e la Fame*, 98 (Bologna, 1602). Beckmann, *Beytraege zur Geschichte der Erfindungen*, 4:387–388, note 6, says that he has not seen Segni's book which Haller cites from Seguier giving its publication as at Bologna in 1602. Beckmann's description of this drill, taken from Zanon, *Dell' agricoltura, dell' arti e del commercio; lettere di Antonio Zanon*, in *Venezia*, 3:325 (1764), who had taken his from Segni, is almost identical with that given by Sighinolfi. The German edition and the second English edition (1814) give Zanon's description. Sighinolfi quotes Cavalini's will, in which the drill is mentioned, from *Archivo Notarile, Rogito di Tomaso, q. Domenico Passerotti, Testamenti, Prot. P.c. 212 v. 1. dicembre 1586*. Feldhaus, in *Die Technik*, erroneously dates the Cavalini drill as between 1500 and 1525 (Cavalini was born in 1520) and cites Giovanni Battista Segni, *Trattato sopra carestia* (Ferrara, 1591).

Allen, *Digest of Seeding Machines*, [v], reproduces an illustration of Locatelli's drill but erroneously calls it that of Cavalini and gives the date as 1605. Allen had evidently seen some of the sources, and has some of the facts correct but his account is so inaccurate as to be quite unreliable.

On November 19, 1580, Tadeo Cavalini applied to the Senate of Bologna for a patent on a grain drill which was granted five years later. The exact details of this grain drill are somewhat uncertain. It consisted of a box frame supported by two wheels, and iron funnels which caught the seed and conveyed it to the ground through tubes which were shaped at the lower end like plow shares or the later drill shoes. The upper part of the body of the drill was the seed-box from which the seed dropped through holes that were closed by a sliding bar. Below this seed-box was the seed-dropper, the details of which are, unfortunately, none too clear. Segni, writing in 1602, shortly after Cavalini's death, compared the dropping device to a flour bolting frame. It may have been built like a bolting frame with a covering of open material through which the seed dropped as it revolved, as a hexagonal prism with rows of holes from which the seed dropped, or, as seems more likely, as a cylinder in which were cavities to receive the seed as the cylinder rotated under holes leading from the seed-box above. Italian scholars, in reconstructing Cavalini's drill, have chosen the latter view and have made a cylinder much like that used later by Locatelli, but with seed cavities like those of the later Tull drills. It seems likely that the seed was immediately covered but by what means is somewhat conjectural.

To the two elements contained in the Babylonian drills Cavalini added the third, the revolving seed-dropping device. How successful this dropper was we do not know nor can we be positive about the exact details of construction but it seems proper to give to Cavalini the credit for having combined the three essential elements in a grain drill. Further information may disclose that the honor belongs to Tarello, or even, in proposal at least, to John Worlidge of England in the following century.

The next milestone was the drill invented by Locatelli. It has been suggested that he may have learned of Cavalini's drill, improved it, and brought it forward as his own. However, in view of the fact that his drill utilized an ordinary plow as a furrow opener, that it had no seed-pipes, and that it apparently used a somewhat different type of seed dropper, there seems to be little or no relation between the two machines.

In 1662 Joseph Locatelli, of Carinthia, Austria, invented a grain drill which had two of the necessary elements, the revolving

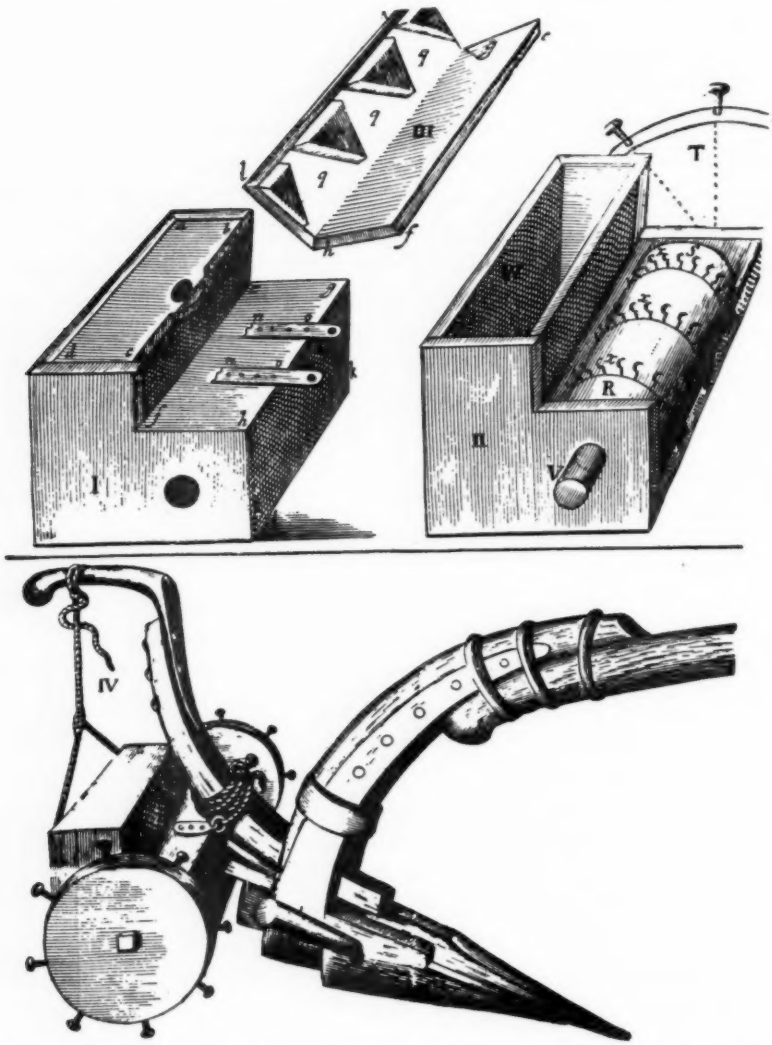

FIG. 4. Locatelli's grain drill. From Royal Society of London, *Philosophical Transactions*, 1670.

seed-dropping mechanism and the drill shoe. In that year trials were held at the imperial palace at Laxenburg, near Wien by

order of Emperor Leopold I, and in the presence of a commissioner, Pietro Bonaventura von Crollolanza, who was designated for the purpose. The results of the trials were so satisfactory that the emperor gave him a reward and letters of recommendation to King Philip IV of Spain, who appointed Don Geronimo de Camargo to conduct trials of the grain drill, or sembrador, as it was called. As a result of these trials Locatelli was given a patent or exclusive privilege of manufacturing and selling these drills in the Spanish realm.

Locatelli's drill, as described in the *Philosophical Transactions* of the Royal Society of London, was attached to the Spanish plow of the period. It was a symmetrical plow with a nearly horizontal plow-stock which became higher and wider as it receded from the point. On each side of the stock was an oblique wooden pin or ear which served as a rudimentary moldboard. The drill proper consisted of a rectangular seed-box supported by a wheel at either end. (The wheels were smaller on the earlier machines than on the one described in the *Transactions*). The seed-box was divided into two parts, the first holding the seed and the second containing the seed-dropper. This device consisted of a wooden axle or drum into which were placed four rows of small brass spoons (at first made of tin), which, with the turning of the drum, caught the seeds in the lower part of the box and dropped them into funnels from which they fell to the ground. This drill, which was tied closely to the plow, sowed the strip as plowed. Like the Babylonian drills, it had a drill shoe in the form of a plow, but it had no seed-pipe to insure accurate and even placing of the seed. Its contribution was a seed-dropping device of a type which has proven successful. It is the common type of dropper in use in Europe today and will be referred to later.[9]

[9] For a complete description and illustrations of Locatelli's machine, see Royal Society of London, *Philosophical Transactions*, 5 (60):1055–1065 (June 20, 1670). John Evelyn, who transmitted the description to the Royal Society, had seen an account of it in a Spanish work dedicated to Signor Don Geronimo de Camargo, and upon his request for information the account was translated from the Spanish by the English Ambassador, the Earl of Sandwich. Beckmann, *Beytraege zur Geschichte der Erfindungen*, 4:386, states that this Spanish work was printed with the approbation of the Austrian, Crollolanza, and dated Aug. 1, 1663, the same date on which Locatelli received the certificate from the representative of the Em-

peror, but he gives no authority for the statement. Inasmuch as Don Geronimo de Camargo had not been appointed to hold trials—Locatelli not yet having gone to Spain—it seems scarcely possible that the work could have been published at that time although it might have carried that date. Evelyn's account specifically refers to the certificate given at Wien on Aug. 1, 1663 (after the harvest of the grain sown in 1662), mistakenly gives the spelling as Lucatello, and refers to the trials as having been held in Luxembourg, Austria, instead of Laxenburg. He also states that many persons came to Madrid from all over Spain as a result of publicity and that trials were held in various parts of the country in 1664. As the original machine was not durable, the wheels were enlarged and made more substantial, brass spoons were substituted for tin ones, nails were added to the wheels to increase traction, and the iron work was strengthened. Evelyn described the improved form. Beckmann, 383–387, gives an account of the invention and a discussion of the contradictions in the sources. His 1799 and 1814 editions state that a reversed figure on a reduced scale but without text is to be found in Leske, *Abhandlungen zur Naturgesch. Physik und Oekonomie aus den Philosoph. Trans.* (Leipzig, 1779). He says that his information concerning the drill was taken from the English account, and a small illustrated work of two quarto sheets in his possession, *Beschreibung eines neuen Instruments, mit welchem das Getreide zugleich geackert und gesäet werden kan; vormals erfunden von Locatelli, Landmann im Erz: Herzogthum, Carndten, Anno 1603.* The name of the printer and the place of publication are not given, and the date is of importance and subject to criticism. Beckmann says that Reimmann gives the date as 1690 but gives no place of publication, that Haller states that it was published at Jena in that year, and that Iöcher, presumably in his *Dictionary of Learned Men*, says that it was printed at Wien in that year. He says that Muenchhausen and Haller (an apparent contradiction with an earlier statement) read the date as 1603. In view of the fact that Locatelli received a certificate from the Austrian Emperor in 1663, the date 1603 can hardly be supported. Beckmann states that his copy has an "o" which appears to be a broken 9. He, therefore, reads the corrected date as 1693 and assumes that it is a reprint of a work which he thinks was published in 1690. It may have been 1663 which corresponds to Beckmann's date for the Spanish work. The drill is described and illustrated in H. L. Duhamel du Monceau, *Traité de la culture des terres*, 1:368, pl. 6 (Paris, 1753), who errs in intimating that the Spanish trials preceded those in Austria and incorrectly says that they were made in Luxemboug [*sic*], Istria rather than in Laxenburg, Austria. The second edition of the English form of H. L. Duhamel du Monceau *A Practical Treatise of Husbandry*, 434–435 (London, 1762), gives a short description of this drill and three figures showing the seed-box. Busch, *Versuch eines Handbuchs der Erfindungen*, (6):9 (Wien and Prag, 1801), refers to Locatelli's drill but states that the Austrian trial was in 1665. Feldhaus, in *Die Technik*, 888–889 (1914), speaks of Locatelli as being from Klagenfurt and of the invention of the machine in 1636 (obviously a typographical error for 1663 which is one year too late). He follows Busch in dating the Austrian trial in 1665, and cites Locatelli, *Beschreibung Eines Neuen Instruments mit welchem Weitzen Korn Haber . . . kann . . . gesäet werden* (1690). This appears to be the work referred to by Beckmann as having been printed in 1603, 1690, or 1693. Braley, in the *Hardware and Implement Journal*, 35 (4):25–27 (April 1930), mentions that the drill was invented in 1662 and makes the statement, not

As mentioned above, it appears probable that Cavalini first used the drill shoe, the revolving seed-dropping device, and the seed-pipe in one machine. Locatelli improved one of these ele-

FIG. 5. Grain-drill models, late Tullian, Locatelli, and Worlidge, in the Museum of Science and Industry, Chicago.

ments, the dropper, but omitted the seed-pipe. In 1669, the year before Locatelli's drill was made known in England, John Worlidge published his book, *Systema Agriculturae*, wherein he described and illustrated a grain drill combining the three ele-

borne out by the Evelyn account, that the Earl of Sandwich saw the machine at Luxemburg. Braley's reference to Luxemburg may be due to Evelyn's error in speaking of Luxembourg, and his illustration of Locatelli's drill is erroneously captioned, "Roman, 1605 A.D." It was evidently taken from Allen, *Digest of Seeding Machines*, who contributes nothing to our knowledge of the drill except the alleged statement that about 1669 an agent was in London to sell this drill, and a cut of Locatelli's drill (from Evelyn) which he credits to Cavalini, 1605. Feldhaus has in his collection a cut of a grain drill after a picture by von Schudi in 1721. The chief differences between this drill and the earlier form are in the shape of the plow (which is not a part of Locatelli's invention), the form of the seed cups, and the number and position of the holes in the bottom of the seed-box. J. W. D. Korth, in Kruenitz, *Encyklopaedie*, 129:487–488 (Berlin, 1821), mentions Locatelli but gives the date of the Laxenburg (or Laxemburg as he spells it) trial as 1665. Except for this error Korth follows the Evelyn account in the *Philosophical Transactions*. Korth gives no cut nor does Otto Sack, "Aus der Geschichte der Drillmaschine," in *Die Technik in der Landwirtschaft*, 10:154 (Juli 1929). Sack's account is taken from Korth and contains the same erroneous date of 1665. Beckmann says that Iöcher, in his *Dictionary of Learned Men*, gives some information concerning Locatelli. For an article and bibliography on Locatelli, see *Allgemeine Deutsche Biographie*, 53:770 (Leipzig, 1907).

ments in a form in which they were successfully used. There is no evidence that such a drill was ever built, but the ideas were, for the most part, clearly presented and may well have influenced later inventors, such as Tull.

Worlidge's drill had a rectangular wooden frame. Behind the iron drill-shoe spread at the bottom was a curved wooden seed-pipe leading from the dropper above. This dropper was an important contribution of Worlidge to drill construction. From this device began the fluted force feeds so commonly used in America. It consisted of projecting strips of leather set in a wooden wheel. These strips, together with the rim of the wheel and the sides of the enclosing case, formed pockets which filled with seed as the wheel was rotated below the hopper opening by means of a belt to a pulley on the back axle. Incidentally Worlidge suggested a fertilizer attachment similar to that for sowing seed with which pigeon dung could be strewn.[10]

Despite all the apparent activity devoted to perfecting the grain drill it remained a plaything in the hands of experimenters until it was improved and popularized among the progressive farmers by Jethro Tull in the eighteenth century. He became the leader of the movement known as the English Agricultural Revolution, which, beginning in a small way during the early decades of the century, came into its own after 1750, when the Industrial Revolution lent its encouragement to more efficient agricultural production. With the beginning of the concentration of population in the rising industrial cities, the inducements were strong to increase the yield and reduce the labor in raising wheat. One of the prominent features of this new agricultural movement was the drilling of root and forage crops and grains, so they might be hoed more conveniently.

Having observed that sainfoin, used for hay and pasturage, was often best where some of the seed had miscarried, Tull investigated the matter with a view to taking his land out of tillage and laying it down to that crop. He experimented successfully on

[10] Worlidge, *Systema Agriculturae*, 46–50, with a cut on 47 (London, 1669). This description was reproduced by Monceau, *Practical Treatise of Husbandry* 429–434, with a cut, fig. 1, pl. 4, following 434.

the depth of sowing and the amount of seed required by making channels and "drilling" or sowing the seed by hand. The next year, his laborers, fearing the ultimate loss of their work in tillage, struck against this innovation, and he dismissed them, resolving at the same time to devise a machine to do the work of the recalcitrant farm hands.

He drew upon his knowledge of mechanics, particularly the parts of the soundboard of the organ with which he had become familiar in his youth. His first seeding device was built on the frame of a wheelbarrow. He enlarged one of the iron gudgeons to an inch and a half, made cavities around it to receive the seed, and placed it through the seed-dropper case which he made in the ear of the wheelbarrow. As the wheel turned, the seeds were dropped by this device into open furrows and then covered by a light harrow. About 1701 he made his first drill for seeding sainfoin and wheat, describing it as one which made channels, drilled the seed, and covered it. He made a number of variations of his drill, but all had the same type of seed-dropper, a cylinder with rows of cavities which received the seed from the seed-box and dropped them evenly into the furrows.

The Tull drill for wheat, described and illustrated in the first folio edition of his book, *Horse-Hoing Husbandry* (London, 1733), may be considered typical of his machines. This drill, which sowed three rows of seed, was drawn by one horse. The three coulters or hoes were narrow and shaped to enter the soil readily. At the rear of the coulters were passages, open behind, which served to guide the seed from the funnels above to the channels in the ground. These coulters, the framework supporting them, and the shafts rested upon the ground and not upon the four wheels of the machine. The two large wheels in front carried the seed-box and dropper unit which fed the center coulter on a $1\frac{3}{4}$ inch axle. Two smaller wheels at the rear carried the droppers and seed-boxes feeding the two other coulters, placed 14 inches apart and some distance back of the central coulter so there would be no interference between them—an arrangement much used during the last century. The dropper unit consisted of the case at the bottom of the seed-box, and the notched axle which

passed through it. This axle, with its notches or cavities in the periphery, turned with the wheels, received the grain from the boxes above, and dropped it into the funnels below. The passage of grain past the notched dropper was controlled by a brass cover and an adjustable spring, patterned after the tongue in the organ mechanism. In principle this dropper is similar to that presumably used by Cavalini and to one of the droppers used in Europe today. Worlidge had suggested what were in effect cavities made by inserting projecting leather fins in the

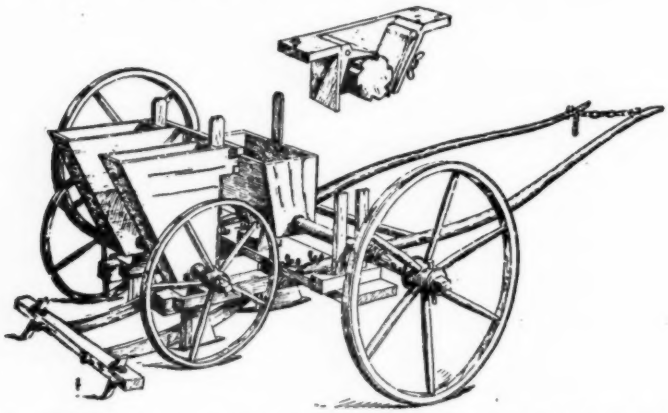

FIG. 6. Jethro Tull's grain drill. Drawn from the sketch and description in his *Horse-Hoing Husbandry* (1733). Note the form of the seed dropper (inset) and the drill shoe.

dropper wheel, but his device had more in common with the fluted force feeds of later times than with those of Cavalini and Tull. Tull may have been influenced by the proposal of Worlidge and Evelyn's account of the Locatelli drill although he stoutly denied dependence upon other drill inventors.

Diderot's *Encyclopedie* (1775) has an extended description and detailed cuts of a drill "after Tull, Duhamel and others." This was an enlargement and except for the poorly designed shoes, a material improvement over Tull's earlier machine. It had a two-wheel fore-carriage whose axle carried a sprocket which drove the seed dropper. This consisted of a heavy shaft with six large wooden cylinders, each in its own compartment, with cavities in

the rim for the seed. The seed-pipes formed parts of the broad-nosed drill shoes. Three pointed shovels were provided to assist in covering the seed.[11]

Although numerous grain drills were invented in the eighteenth century, most of them failed to perform satisfactorily and were of little consequence. However, certain of these machines were of sufficient importance to merit some attention. Even those which failed as machines may have contributed elements of success or lessons in what to avoid. They certainly bear witness to the earnestness with which men were attacking this problem.

Chateauvieux followed the general principles of Worlidge and Tull. He used a two-wheel fore-carriage which carried some of the weight of the drill proper. The seed was placed in a box, through the lower part of which extended the seed-dropping cylinder which was turned by belts from the wheels. Whereas the improved Tull drill had used six large wooden discs with cavities in the rims and separated so as to be over the furrows, this drill had rows of cavities crowded close together on a relatively small metal cylinder. As this cylinder turned, the seeds were picked up from the seed-box and deposited in tubes through which they dropped to the rear of the drill-shoes into the furrows and were covered by small shovels. The machine was controlled by two handles at the rear. · It was reputed to be very successful

[11] The best sources of information regarding Tull's drills are his own publications, *Specimen of a Work on Horse-Hoeing Husbandry* (London, 1731), the folio edition, cited in the text, with plates (1733), and the *Supplement* published in 1736. See also Cathcart, "Jethro Tull: His Life, Times and Teachings," in Royal Agricultural Society of England, *Journal* (ser. 3), 2:1–40 (1891); *Gentleman's Magazine*, 34:532–533, 632–634 (November 1764). The text covering the modified drill is found in Diderot, *Encyclopédie*, 14:886–887 (ed. 3, 1775), and the cuts in *Recueil de Planches*, 1, "Agriculture, Semoirs", pls. 1–3. Tull's drill is mentioned in Busch, *Handbuchs der Erfindungen*, (6): 9 (1801). A discussion of Tull's methods but little of his drill is found in Loudon, *Encyclopaedia of Agriculture*, 125–126. In fact most of the books on British agriculture published after the time of Tull discuss the "new husbandry." Tull may have seen a publication by the Marquis of Boro, dated 1669 and dedicated to Lambert Blackwell, an Englishman, which described a grain drill called the "Wagon of Ceres." See Sighinolfi, *Taddeo Cavallini, Inventore Della Prima Seminatrice per Cereali*, 7–8. Tull says in his *Supplement*, 243, that after the publication of his earlier work he saw a copy of Worlidge's book. A cut of Tull's drill is reproduced from his 1733 edition by C. M. Waters, *An Economic History of England*, 277 (London, 1925).

although there appears to have been little that was new in its construction. One of its good features was the shoe which, like Tull's early shoe, was made narrow and with a point resembling that of a plow instead of the later Tullian broad-nosed shoe which would enter the ground with great difficulty.

The drill of de la Levrie was somewhat similar in general design to that of Chateauvieux. However, the cylindrical seed-dropper had the rows of cavities separated. It had one interesting peculiarity, later found in the Cooke, Bedfordshire, and Gautreau drills. The seed-box was hinged so that the quantity of seed sown could be changed by tilting the box back or forward.

Another drill which had a good reputation in its day was that invented by James Cooke of England in 1782 and patented the following year. He used the spoon type of feed, seed-pipes, drill-shoes, and spike-like shovels to cover the seed. One innovation was the use of gearing instead of belts and chains to turn the dropper unit, as used by Worlidge, Chateauvieux, and de la Levrie, or direct action from the supporting wheels as used by Cavalini, Locatelli, Tull, Duhamel du Monceau and others. Cooke's drill in its various improved forms was most commonly used in the century following the death of Tull in 1740.[12]

[12] Chateauvieux's drill is described in detail in Kruenitz's *Encyklopaedie*, 129:502–573, and pls. 2–6 with 100 figs. A shorter account, with an illustration, taken from the above is given in Sack's article cited above. The *Complete Farmer* (London, 1764) has a nineteen-page article on grain drills, with five large plates, four of which cover the details of Chateauvieux's drill. The article also covers the drills of Worlidge, Locatelli, and Duhamel du Monceau. De la Levrie's machine is described in Kruenitz, *Encyklopaedie*, 129:573–584 and pl. 7 with 5 illus., and by Sack, *Aus der Geschichte der Drillmaschine*, 156. For James Cooke's machine see Kruenitz, *Encyklopaedie*, 129:584–599 and pl. 8, fig. 7369; Sack, *Aus der Geschichte der Drillmaschine*, 157; Feldhaus, *Die Technik*, 889; Loudon, *Encyclopaedia of Agriculture*, 387, and the English patent numbers 1389 and 1659. Kruenitz, chiefly on pages 488–489, mentions the drills of Randall, Arbuthnot, Luigi Ricetti, Harduino, Mongeon, Westbeck, Thunberg, Cronstedt, Ignatius Ranconi, Winter, de Lisle, Jouvet, Schiffeli, Gennette, de Montesini, de Villiers, Thorne (with a reference to *Memoir sur la Pratique du Semoir*, Lion, 1760–1771), and "W.v.M." whose drill is described at some length in *Hannoverische Beytrage*, (59):939–942 (Julius 23, 1762); (96):1521–1530 (November 29, 1762), and *Hannoverisches Magazin*, (5):74–80 (Januarius 1763). The impractical-looking drill invented by Randall is described and illustrated in *Gentleman's Magazine*, 34:460

Albrecht Thaer of Germany, a close student of agricultural practice who was familiar with the earlier work on grain drills, invented a drill in 1804, which was evidently a material improvement over any previously made. Thaer had admired the drill of Ducket of England and followed his design. He added no new principles but he produced a more workable combination than any hitherto secured. This horse-drawn drill followed the usual two-wheel design. The dropping mechanism consisted of a shaft geared to the main axle and carrying six small wheels with cavi-

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(October 1764). Modern German drills are described and illustrated by Ing. Vormfelde, "Landmaschinen," in F. Aereboe, J. Hansen, and Th. Roemer, *Handbuch der Landwirtschaft*, 3:99–111 (Berlin, 1930), and Georg Kühne, *Handbuch der Landmaschinentechnik*, 1:267–292 (Berlin, 1930). For the Bedfordshire drill, see J. M. Wilson, ed., *The Rural Cyclopedia, or a General Dictionary of Agriculture*, 4:284–285 (Edinburgh, 1852).

The revolving cylinder from which seed is dropped has been used in various forms. Duhamel du Monceau proposed a seeder which consisted of a hollow drum divided into three sections with a row of holes running around each. This was mounted on an axle from which was supported the drill shoes and funnels. He took his idea from a seed-box invented by a man named Grenville, one of the pages of the French king's stables. See Monceau, *Practical Treatise of Husbandry*, 438, and the article on drills in the *Complete Farmer* (1764). The Abbot Soumille devised a hand drill with a dropper of this kind. It had one wheel and was pushed along in the furrow after an ordinary plow. The seed was covered by the succeeding furrow slice of the plow. See Diderot's *Encyclopedie, Recueil de Planches*, 1:1 and pl. 1, fig. 4, "Agriculture, Labourage." The date of Soumille's drill has not been found. It is mentioned in Baron Ogilvy's address of 1761. See Kruenitz, *Encyklopaedie*, 129:490. This drill is also mentioned in Busch, *Handbuchs der Erfindungen*, 6:9. Ducket, in England, invented a roller seeder or drill which was highly commended by Thaer. See Kruenitz, *Encyklopaedie*, 500, 599–614, figs. 7370–7399. An account by Sack, taken from Kruenitz, is found in *Die Technik in der Landwirtschaft*, 10:153, 187 (July, August, 1929). George Washington devised a drill with this principle, using a tobacco hogshead with rows of holes from which the seed dropped as it was rolled over the field. See W. E. Brooke, ed., *The Agricultural Papers of George Washington*, 17, 34–36 (Boston, 1919). Moodie, in England, devised a roller-type seeder for turnip seed. The framework had shafts for the horse and two concave rollers which made ridges upon which the seed was sown. Over each ridge was a drill shoe and a revolving cylinder dropper which was kept filled to the same depth at all times from a separate seed-box on the side. Newberry's horse dibble employed the cylinder type of dropper. See J. C. Morton, ed., *A Cyclopedia of Agriculture*, 2:887–888, 890–892 (Glasgow, 1855).

ties in the rims. The drill shoe was a symmetrical shovel with a projecting digging-point.[13]

The Tull system or the "new husbandry" emphasized the sowing of grain, forage, and root crops in rows with drills and cultivating them by means of horse hoes instead of practicing the unsatisfactory hand hoeing or fallowing. Tull advocated throwing up ridges 4, 5, or 6 feet wide by means of a plow, and drilling three rows of wheat, 7 inches apart in the middle of each ridge. The space between was to be cultivated with what Tull called a "ho-plow", which was more like an ordinary plow than a cultivator as we know it. The "system", particularly as applied to grain, was never adopted in its entirety, although the stimulus to better farming in general and the use of the grain drill in particular were important results of his work. He lived but nine years after he first published an account of his work, and these years were marked by bitter controversy with certain writers of the day.[14] While it is proper to give great credit to Jethro Tull for his contributions to the development of the grain drill and the triumph of drill husbandry, it must not be supposed that the practice became widespread in his day. Lord Ernle says that Tull's "method of drilling wheat and roots in rows was not generally adopted till many years after his death. But the main principles which he laid down in his *Horse-Hoeing Husbandry* proved to be the principles on which was based an agricultural revolution in tillage."[15]

The series of county surveys of the agriculture in England about 1800 reveal that drilling was far from common in most parts of the country. In some counties drilling was unknown while in others some experiments had been carried on by the more progressive farmers. In most sections the utility of the grain drill appeared to be an open question, and it had a strong rival in the dibble. Progress in drilling seems to have been greatest in Nor-

[13] See Kruenitz, *Encyklopaedie*, 129:614–626 and pls. 14–16, and Durer, *Albrecht Thaer*.

[14] See Tull, *Horse-Hoing Husbandry*, i–vii, 25–37, 122–131 (1733), and the *Supplement* (1736). The new husbandry is discussed in *The Complete Farmer or General Dictionary of Husbandry* (1764).

[15] R. E. Prothero, *English Farming, Past and Present*, 169 (London, 1917).

folk and Suffolk, perhaps because of favorable soil conditions and the presence there of some of the leaders of the new agricultural movement, among them Coke and Townsend. Even there the use of drills was by no means common about the year 1794, but in the next decade a remarkable change took place. Arthur Young, in his report on Suffolk in 1804, said that "a revolution has taken place in the agriculture of the strong [i.e., heavy] land district; for drilling in many parishes is become universal, except in the southwestern angle of the county; and promises to spread every where. . . . The success in Suffolk has been very great indeed. . . ." He reported that generally the use of the drill was most widespread on the lighter soils.[16]

However, the use of the drill gradually spread in those districts which were distinctly grain-growing areas. The most prominent drills in England until well into the nineteenth century were the improved forms of James Cooke's machine, described above. That used about 1825 had large wheels which enabled it to travel readily, a means of keeping the seed-box level and supplying an even quantity of seed to facilitate regular distribution, and a cup feed driven by gears from the axle. It had six coulters arranged in such a manner that they moved together from side to side on the principle of the pantagraph so that the straightness of the row might be maintained, and a means of raising and holding the coulters out of the ground when turning.[17]

[16] The following volumes among the surveys prepared for the Great Britain Board of Agriculture: *General View of the Agriculture of the County of Suffolk*, 69–70, 74–75, 350–408 (Ed. 3, London, 1804); *Norfolk*, 38 (1796); xv, 33–35, 58–59, 275, 293, 348–362 (1804); *Lincoln*, 70, 138–141 (1799); *Kent*, 53 (1805); *Northumberland*, 213 (1805); *Middlesex*, 166, 168 (1798); *East Lothian*, 68–69 (1805); *Shropshire*, 159 (1803); *North Riding of Yorkshire*, 113 (1800); *Hertfordshire*, 126–132 (1804).

[17] Loudon, *Encyclopaedia of Agriculture*, 386 and numerous references through the series of surveys cited in footnotes 16 to 20. Other drills in use were those of Ducket, Perkins, Wellard, Amos, and Morton. *General View of the Agriculture of Hertfordshire*, 126–132 (1804); *North Riding of Yorkshire*, 85 (1800); *Roxburgh and Selkirk*, 53 (1798); *Kent*, 53 (1805).

A drill roller or presser, apparently invented by a man named Berriman of Speen, was in use in Norfolk late in the eighteenth century and was still in operation, particularly in Berkshire, about 1840. It was similar to the heavy corrugated rollers of the present time and made troughs in the soil into which fell the seed, sown broadcast or from a seed-box. A light harrowing completed the seeding. *General View of the Agriculture of the County of Norfolk*, 58 (1804); *British Husbandry*, 2:142–144 (London, 1841).

The use of dibbling persisted during these years. While it had been known, and to some extent practiced from early times, as noted above, it was not generally introduced into England until about the middle of the eighteenth century. At the time when drilling was being introduced, dibbling was, strangely enough, also increasing. Charles Varlo, in writing of the agriculture of Norfolk in 1796, called dibbling "one of the most valuable improvements that, perhaps, ever appeared in agriculture." In Lincolnshire it was reported that "Upon the whole, it [dibbling] has succeeded greatly."[18] Among the advantages frequently given for its adoption was that it provided employment for the poor. It also encouraged the farmers to weed their crops more thoroughly and thereby employ more labor. One writer in Norfolk took pious pleasure in the fact that dibbling resulted in the employment of thousands of the parochial poor children who would otherwise be without employment at that season.[19] About 1800 the cost of dibbling was about 8s. 6d. to 10s. per acre but in 1840 it had dropped to about 7s. 6d. A dibbling crew consisted of one man and from two to six children. The man walked backward on the well-rolled ridge and, with two dibbling irons, made with a cross grip at the top and a conical point at the bottom, made two rows of holes about 2 inches deep and 3 or 4 inches apart on every other flag or furrow slice. The children, who were kept at some distance from each other to prevent their talking, dropped three or four grains into the holes which were then covered by means of a bush-harrow. A younger child who could drop into one row of holes was paid 3d. per day while those who could drop into three rows received 10 1/2d. Only two were required to follow one man, who could, if expert, hole half an acre a day.[20] Dibbling of wheat was common in the eastern counties as late as the middle of the nineteenth century. Bentall's seed depositor was designed for the use of children in drop-

[18] *British Husbandry*, 2:82–84 (London, 1841); *Norfolk*, 207, also 38, 200–208 (1796); *Lincoln*, 142 (1799).

[19] *Suffolk*, 65–66, 68, 69 (1804); *Norfolk*, 203–207 (1796).

[20] *Suffolk*, 69 (1804); *Norfolk*, 203 (1796); *British Husbandry*, 2:83 (London, 1841).

ping seeds into holes previously made. The seeds were dropped through holes in a rotating plate which was moved by a sliding handle. Crawford's hand dibbler of the same period employed a dropping device consisting of two sliding bars and having a needle valve at the bottom. Another dibbler, invented by Dr. Newington, had a slide dropper operated by the handle and seeding nine holes at once.

The difficult task of adapting dibbling to a horse drawn implement was performed by J. W. Newberry of Oxfordshire. His seeder, covered by a patent issued in 1840, consisted of a shaft with five (later seven) wheels having projecting dibbles and provided with separate feed-tubes from the seed-box above. The dibbles were divided longitudinally into halves. As the dibble left the ground one portion of it, which was hollow, slid down allowing the seed to fall in the hole. Some of the machines were made but they did not come into general use.[21]

Although dibbling machines were thus used in England at least until the middle of the nineteenth century, they failed to meet the needs of the grain raiser and dropped out of use. The road to a successful seeder did not lie in that direction. These devices, some complicated and all impracticable, are of interest principally as an example of how earnestly man was striving to perfect a machine for the more satisfactory seeding of grain.

Drilling came into use in the United States much later than in England and spread slowly. It must be kept in mind, however, that agriculture on the new lands of America was in a very different phase of development than in Europe. Farmers were pushing into newer regions, little capital was available for machinery, and much of the soil yielded good crops even with careless culture. Before taking up the evolution of the grain drill in the United

[21] Morton, *A Cyclopedia of Agriculture*, 2:903–906, pl. 39 and figs. 854–857. Newberry's patent is no. 8294 (June 1, 1840). The seed was fed to the dibbling wheels by means of notches in the periphery of a seed roller. Henry Colman, *European Agriculture and Rural Economy*, 2:229 (Boston, 1848). In 1860 Leonard Hariman was granted a United States patent on a grain drill having six rows of dibblers and a revolving seed case. Allen, *Digest of Seeding Machines*, 128, 173.

States it will be desirable to summarize briefly the spread of the practice of drilling.[22]

Although a drill patent had been issued in the United States in 1799 and some English drills had been imported, drilling may be considered as virtually unknown before 1840. Jesse Buel, editor of the *Cultivator* and one of the leading agriculturists of his day, knew very little about drilling in 1839 and looked upon the drill as a distinctly British implement. Incidentally New York, particularly the Genesee Valley, was still the chief wheat-raising section of the United States and, therefore, the most likely to make use of improved methods. Northern Delaware was one of the first areas to use the drill, yet there was reported to be only one drill in the State in 1843. During the early forties, the drill spread slowly from a nucleus in New Castle County, Delaware, and Chester County, Pennsylvania, into Virginia and Maryland, and particularly through eastern Pennsylvania and up into the wheat sections of New York. New England, which was no longer a factor in wheat production and which had an inhospitable soil, knew but little of the new mode of seeding. Throughout the country the word "experiment," appeared frequently in the contemporary descriptions of grain drilling during the forties and even the fifties. Allen, writing in 1849, indicated

[22] Perhaps the best summary of the spread of grain drilling in the United States is that in Leo Rogin, *The Introduction of Farm Machinery in its Relation to the Productivity of Labor in the Agriculture of the United States during the Nineteenth Century*, 192–199 (Berkeley, Calif., 1931). Special mention may be made of the following sources: Jesse Buel, *The Farmer's Companion*, 151–152 (Boston, 1840); *American Farmer*, 1:252–253 (February 1846); 2:84–85 (September 1846); 3:371 (June 1848); 6:65, 76–77 (August–September 1850); R. L. Allen, *The American Farm Book*, 96, 131–132 (New York, 1849); U. S. Patent Office *Report of the Commissioner of Patents* (1850): county reports; New York State Agricultural Society, *Transactions* (1854) 14:293; *Cultivator*, 8:43–44 (March 1841); (n.s.) 1:44 (February 1844); Michigan State Board of Agriculture, *Report* (1864), 3:145–146; (Illinois citation), *Report of the Commissioner of Agriculture*, 1863:428, and *Country Gentleman*, 30:107 (August 15, 1867); 36:692 (November 2, 1871); county reports scattered through the Iowa State Agricultural Society *Reports* for 1857, 1858, 1860, 1866, and 1867; *Report of the Commissioner of Agriculture*, 1874:60–67; *American Agriculturist*, 37:249 (July 1878); 38:298 (August 1879). See also U. S. Patent Office, *Report of the Commissioner of Patents*, 1849:107; 1855:192–198; *American Agriculturist*, 21:76 (March 1862); *American Farmer*, 1:245–246 (February 1846); 3:217 (1848); 5:22 (1849), and references cited by Rogin.

that broadcast seeding was the accepted practice throughout almost the entire country. It was only in a few localities that most of the grain was drilled at the middle of the century.

The Mississippi Valley was slower than the Middle Atlantic States in introducing the drill. A few Ohio farmers had drills in 1844, but it was not until the late fifties that they became common. They were widely used in the level and cleared sections of Michigan by the middle sixties, but were described as "nearly unknown" in central Illinois in 1867. M. L. Dunlap, writing from Illinois, considered drills of little value in 1863, and farmers used them but little in southern Illinois in 1871. Farther west, in Iowa, a few drills had been introduced by 1857, but they were virtually unknown throughout the State and little progress in drill culture had been made by 1866, even with the stimulus of the Civil War.

During the seventies the use of the drill spread rapidly, especially on the level lands of the Mississippi Valley. By 1874 nearly half of the winter wheat and more than a third of the spring wheat of the region was drilled. It will be recalled that wheat farmers, under the stimulus of high prices during the Civil War and the extension of the railroads, had gone beyond the Mississippi, and were producing and shipping out wheat in large quantities. In the East, New England used the drill but little; in the Middle States drilling came to be the accepted practice. By the end of the eighties the use of the drill was widespread and the implement manufacturers no longer had to convince the farmers of its utility.

The first American patent for a seeder was issued to Eliakim Spooner on January 25, 1799. Although thirty seeder patents had been issued by 1836, little of importance had been contributed, and grain drilling had made no headway in any part of America. In fact, there were few farmers who had any first-hand knowledge of the use of the drill.[23]

[23] The most convenient source of information on American seeder patents is J. T. Allen, *Digest of Seeding Machines and Implements Patented in the United States, . . . 1800 . . . to . . . 1878, with a Supplement to January, 1879* (Washington, D. C., 1879); and *Supplement to Allen's Digest of Seeding Machines and Implements, 1879–1882*. From Allen may be secured the data for locating the

A cylinder drill of the Cavalini or Tull type was patented by J. Gibbons on August 25, 1840 and May 4, 1841. It was a small drill, drawn by one horse, with cavities for the seed on the periphery of the dropper wheel. The flared hoe-type drill-shoes extended forward like plow shares.[24] This drill seems to have been little used. On March 12, 1841, Moses and Samuel Pen-

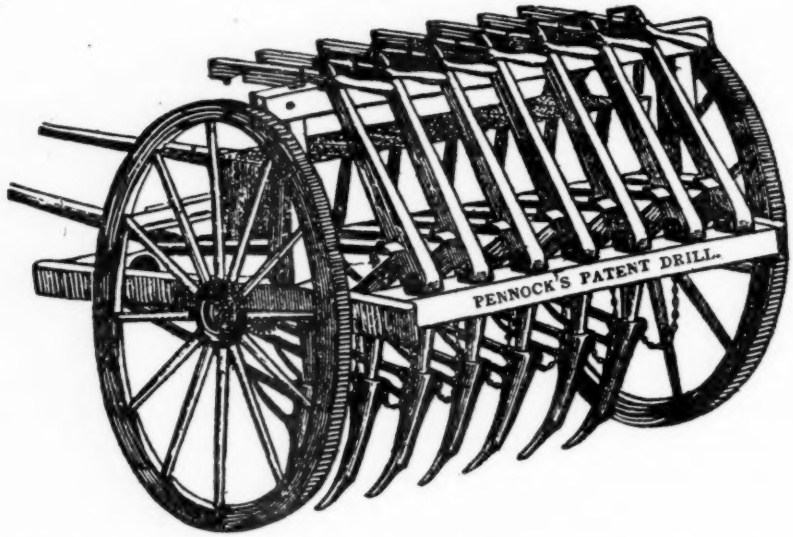

FIG. 7. Pennock's grain drill of 1847. From *Genesee Farmer*, 8:93 (April 1847).

nock of Kennett Square in Chester County, Pennsylvania, received their first patent on a drill which was said to be an improvement on the "Lion" drill, an English implement believed to have been imported into the adjoining county of New Castle, Delaware. From this time until after the Civil War the various Pennock drills were among the most prominent and successful in America. Like all the early American drills, the first Pennock

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patent specifications. See Allen's preface and p. [vi] for information concerning Spooner's patent. At least one English drill was imported into Delaware about 1827–1834. *American Farmer*, 1:245–246 (February 1846); 2:85 (September 1846); 3:217 (January 1848).

[24] Allen, *Digest of Seeding Machines*, 779, 861.

machine was a hoe drill, having seven hoes nine inches apart, and it would sow wheat, oats, Indian corn, peas, turnips, etc., in whatever quantity desired. The dropper unit in this drill included a cylinder or wheel with cavities to receive the seed. By a series of levers any hoe could be thrown in or out of the ground as desired, and it was claimed that it worked equally well on hilly or level ground. One man with two horses could sow from 10 to 12 acres per day. These drills came into use with the season of 1841, particularly in Chester County, Pennsylvania, and New Castle County, Delaware, and won the approval of the farmers within a few years. The general appearance of the Pennock drills changed very little, but in 1850 an adjustable pin break was added to the hoe assembly, and in the following year a new dropper unit having a basic cylindrical shell and two notched or toothed cylindrical gauge cups slipping over it was added. By backing off one of these and rotating it the size of the seed opening was changed and the amount of seed sown varied.[25]

Another popular drill, though much less used than Pennock's, was that of Pierpont Seymour of New York. It was patented on September 25, 1849, and given a premium at the New York State Fair at Syracuse the following year. It seems to have been well received generally. The seeds, agitated by a toothed rod which was made to vibrate by a zig-zag plate, dropped between two parallel bars through a space which could be adjusted to vary the amount sown. This type of dropper unit, while appearing to be successful in this instance, did not find favor with the farmers as did the fluted type and finally disappeared. The hoes, which were regularly placed in one rank, were so constructed that the operator, walking behind the machine, could see whether any of the droppers were clogged. The drill, which could also distribute fertilizer, was made with seven or nine hoes.[26]

[25] U. S. Patent No. 1999; Allen, *Digest of Seeding Machines*, 779, 787, 861, 863; *American Agriculturist*, 1:227 (November 1842); 5:255 (1846); *American Farmer*, 1:245–246 (February 1846); 2:84–85 (September 1846); 3:177 (December 1847); 6:70, 272 (August 1850, February 1851); *Cultivator* (n.s.), 5:329 (November 1848).

[26] Allen, *Digest of Seeding Machines*, 2, 34, 134, 142, 783–784, 862; *Cultivator* (n.s.), 7:273 (August 1850); (ser. 3), 1:165 (May 1853). Seymour's first invention was a sliding-type dropper, the principle of which was used in his later drills.

The Palmer drill—beginning in 1849—also came into relatively extensive use. It resembled the others of that day in general appearance except for a vibrating slide dropper and a mechanism for fastening the hoes. The hoe itself was the usual form but was attached to the seed box by two parallel bars, the lower one having a trough on its upper side to convey the grain to the top of the hoe in sight of the operator who rode on the box. This construction allowed any hoe to be raised separately. Furthermore, if the hoe hit an obstruction it flipped up or at the worst broke a wooden pin provided for the purpose. Concerning Palmer's first drill it was said that "One simple distributor driven by a cam wheel and friction rollers, conveys the grain from the hopper into the several drills, through hollow braces or levers . . ." but the dropper unit of his later drills seems to have consisted of two disks which fit together, one inside the other, in such a way that, by adjusting the two parts, the size of the opening or seed receptacle, and hence the amount of seed sown, could be varied.[27]

The drill patented by Craggs and Reynolds on August 14, 1847, differed in design from that usually found in America. It was a one-horse drill having six "Suffolk type" coulters, such as were common in England, set in two ranks, and three feed disks with feed cups on either side to feed the six coulters. It was clearly patterned after the English drills but never widely used. The Pierson drill, patented on July 5, 1848, had seed cylinders or planting rollers with adjustable cavities in the periphery and, later, a planetary gear to throw the drill out of action.

These drills, together with that of Bickford and Huffman which came into particular prominence later, represented the state of drilling in America before the Civil War. They differed from those in Europe in some important particulars, notably the droppers, furrow openers, and lack of fore-steerage devices, and they were much less intricate, a fact still true of American drills, and sold for about one-third to one-half of the price of

[27] Allen, *Digest of Seeding Machines*, 3, 134, 782, 862; *Cultivator* (n.s.), 6:153 (May 1849); U. S. Patent Office, *Report of the Commissioner of Patents*, 1849:107.

the best English drills.[28] Thomas, writing in 1854, described the American drill as follows:

> A great number of different drills have been made for sowing grain. . . . The seed is delivered by means of a revolving cylinder, in the surface of which small regular cavities have been made, which constantly carry off and drop measured portions of the grain. The motion of this cylinder is increased or lessened by means of wheel-work, according to the quantity of seed to be sown.[29]

An important stage of American drill development came with what is known as the force feed. The antecedents of the fluted cylinder external force feed lie in the dropper proposed by Worlidge nearly two centuries before the principle came into use here. The first American patent on a force feed was that issued on November 4, 1851 to N. Foster, Gilbert Jessup, and C. P. and H. L. Brown. This device differed from the Worlidge dropper in that it consisted of a disk with projections operating within a case having an opening to receive the grain and an outlet into

[28] In 1841 none of the American drills had fertilizer distributors as had many of those in Europe. *Cultivator*, 8:44 (March 1841). The drill patented by H. W. Smith on Nov. 4, 1846 had a divided distributing cylinder with cavities in the periphery, a means of elevating the shoes forward, and an adjustable device for varying the amount sown. Allen, *Digest of Seeding Machines*, 780, 861. For the drill of Craggs and Reynolds, see *ibid.*, 584, 610; *Southern Cultivator*, 6:100 (July 1848). For Pierson's drill, which had a spring trip much like those of today, see Allen, *Digest of Seeding Machines*, 781, 861. For descriptions of other drills, see the *Cultivator*, 2:49 (June 1835) (Craig, and Lewis); 3:125 (October 1836) (Merchant, slide type dropper); 7:141 (September 1840) (Bachelder); 8:195 (December 1841) (Hatch); (n.s.), 5:158–159 (May 1848) (Smith); (ser. 3), 1:96, 302 (March, October 1853); Allen, *Digest of Seeding Machines*, 676, 680 (Willoughby, elastic feed wheel); 780, 861 (Smith); 788,864 (Gardiner, ratchet dropper); 801, 867 (Thomas and Mast, and Richmond); *American Farmer*, 3:77 (September 1847) (Gatling); *Pictorial American Farmer*, 6 (1850). Obed Hussey is said to have exhibited in Baltimore in 1848 a drill of his own manufacture, but he does not seem to have patented it. *American Farmer*, 4:107 (October 1848). About 1850 Sinclair of Baltimore was selling the Maynard drill, which had separately hung, adjustable hoes with pin break, and dropper cylinders "in two parts, and separated or closed by two pinch screws . . . attached to an iron rod, which allows the cups to be formed to any and uniform size, and to drop any desired quantity of wheat per acre." *American Farmer*, 5:60 (August 1849); 6:477 (June 1851); 7:19 (July 1851). For a cut of the Bickford and Huffman drill of the period, see the *Cultivator* (n.s.), 8:209 (June 1851), and the *Southern Cultivator*, 9:138 (September 1851). The same cut was used in machinery catalogs in 1857.

[29] J. J. Thomas, *Farm Implements*, 148–151 (New York, 1854).

the seed tube. These men had been manufacturing grain drills at Palmyra, New York, since 1849. Later the Browns withdrew and founded what came to be known as the Empire Drill Company at Shortsville, New York. On November 20, 1860, Hiram Moore patented a fluted cylinder feed which resembled the Worlidge dropper more closely than the one mentioned above. This was improved by the Van Brunt adjustable gate of November 23, 1869, in which the ribs slid through a rotating head to regulate the amount sown. The adjustable fluted feed with which we are familiar is almost identical with that of J. M. Westcott, patented on April 25, 1876. The ribs on the fluted cylinder slid through notches in a rotating end plate to change the rate of drilling and a non-rotating section which slid through fixed notches in the side wall filled the case when the fluted section was withdrawn. It was this type of drill which dominated in America until recent years and which is still prominent among American machines. In the meantime J. Pierson, in 1848, and M. C. Younglove, in 1858, had invented adjustable droppers consisting of a series of notches or pockets on the side of a cylinder into which were fitted corresponding notches on a sliding sleeve. Van Brunt's patent of November 12, 1861 covered substantially the same idea. The unit consisted of a fluted cylinder upon which slid a slotted sleeve the points of which entirely filled the space between the ribs. By moving this sleeve back and forth the size of the seed cavities could be changed. Although patented in the United States the idea of a sliding member to close off the slots and reduce the quantity sown was not new. It had been used in England about 1805 in almost the same form in Bailey's drill. A fluted feed even more nearly identical with that of Bailey was patented in the United States in 1869 by J. S. Rowell. Over the fluted member there was placed a shell on the end of which projections came down into the grooves. The amount of seed sown was regulated by moving the shell back and forth on the fluted feed roller.[30]

[30] Allen, *Digest of Seeding Machines*, 733, 763 (Foster, Jessup and Brown, and Moore); 742, 768 (Van Brunt); 743, 768 (Rowell); 755, 774 (Westcott); 800, 867 (Younglove); *General View of the Agriculture of the County of Northumberland*, 46–48 (1805) for Bailey.

The internal force feed which now leads in America dates from an invention by Gilbert Jessup, patented June 25, 1861, and assigned to Lyman Bickford of Macedon, New York, and Thomas, Ludlow and Rodgers, and Charles E. Patric of Springfield, Ohio. It was a combination of external and internal feed. On the outside of a wheel was a fluted surface to feed one size of grain while on the side of the disk was a cavity for other kinds of seeds. This would seem to be "double force-feed" advertised by Thomas,

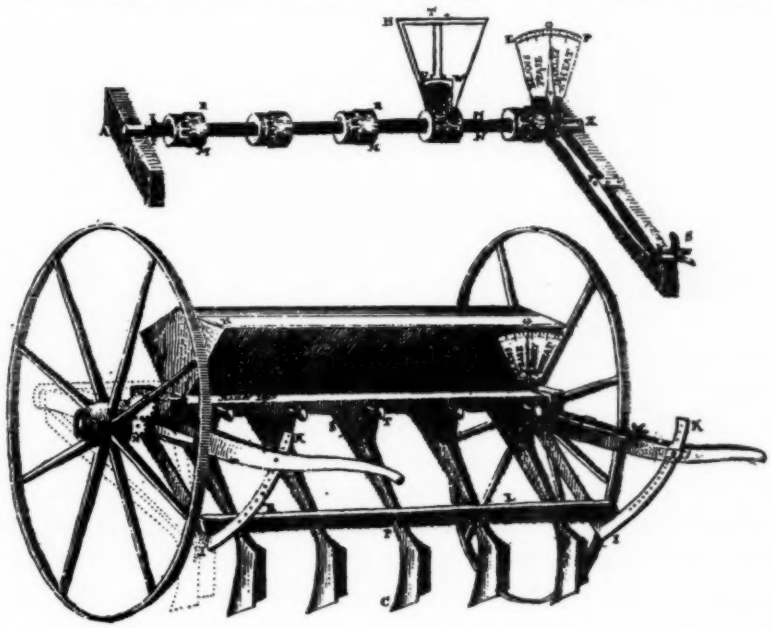

FIG. 8. Bailey grain drill. Note the sliding seed-dropper unit to vary the amount sown. From *General View of the Agriculture of the County of Northumberland* (1805).

Ludlow and Rodgers as having been in use in the early seventies. J. P. Fulghum, in 1874, patented a single-run internal force-feed dropper consisting of a deep shell with corrugations on the inside rim and an adjustable plate to make the cavity deeper or shallower and thereby change the rate of seeding, and C. E. Patric patented an improved single run internal force feed in 1878.

In the meantime, Lyman Bickford (1867) had patented an internal-run disk with a double feed for different kinds of seeds. It consisted of a thick disk with a cavity on each side and flanges extending inward from the rim to pick up the seed. Bickford and Huffman, one of the best known American drill manufacturers of the nineteenth century, made this type of drill. Thus is

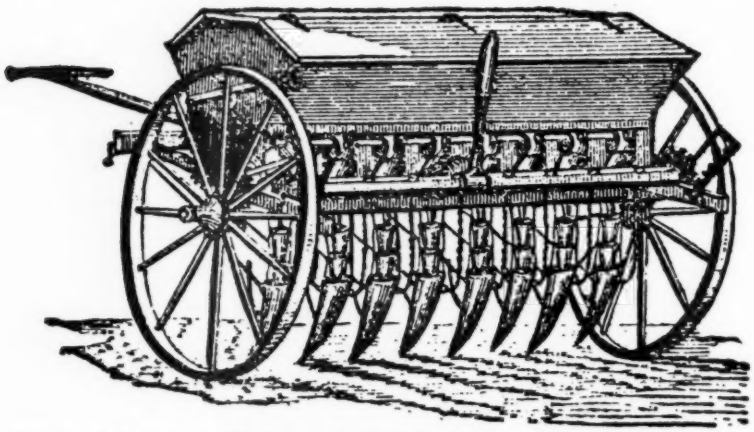

FIG. 9. Bickford and Huffman's grain drill of 1869. From *Cultivator and Country Gentleman*, 34:285 (Oct. 7, 1869).

completed the list of American drill types based upon the dropper unit.[31]

The drills made by Bickford and Huffman of Macedon, New York, won recognition before the Civil War and were the most prominent for several years thereafter. Their first drills were evidently made under patent rights purchased from others but

[31] Allen, *Digest of Seeding Machines*, 734, 764 (Jessup); 737, 765–766 (Bickford); 749, 771 (Fulghum); 1296, 1321 (Patric); *American Agriculturist*, 33:353 (September 1874). A curious dropper with a cone, on the face of which was a number of ribs, was patented in 1878 by J. M. Smith and H. W. C. Thomas but apparently was of little importance. Allen, *Digest of Seeding Machines*, 856, 884.

A hand oscillating seeder with a tube which was placed in the ground and opened to allow the seed to drop out was patented by William Bullock on Nov. 2, 1852. A number of patents covering seeder units with buckets or cups on a wheel or disk were issued in the United States following 1858 but this type of seeder never came into use in this country. Allen, *Digest of Seeding Machines*, 584–596, 610–613, 889–953. Among the drills using a screw conveyor were those patented by R. J. Gatling (1848) and John Milton (1872). See Allen, *Digest of Seeding Machines*, 1061, 1065, 1072, 1074.

later Bickford took out patents for improvements which were incorporated into their own drills. In the fifties their machines were what were known as "iron-cylinder grain drills." In 1861 Bickford received patent rights to the combined internal and external feed-dropper of G. Jessup. Unfortunately the information relative to such details as the actual construction of the dropper into the drill is scanty, but we know that in 1869 their drill, "The Farmers' Favorite," had a double run internal force-feed dropper with an opening controlled by a sliding bottom, evidently built under the Bickford patent of that year. The change of the rate of sowing was effected by changing gear wheels, which could be done only when the drill was stationary. This hoe drill continued for years to lead the American field.[32]

The "Farmer's Friend" drill, manufactured at Dayton, Ohio by the Farmer's Friend Manufacturing Company was fairly successful. It had a unique fluted feed (Benjamin Kuhns dropper) in which the eight ribs zig-zagged across the face of the wheel. It had a force-feed grass seeder, a spring hoe, and a commendable arrangement of gear wheels in a cone that regulated the rate of sowing while the drill was in motion.[33] Another drill well spoken of in the West was that of D. E. McSherry of Dayton which resembled the other drills of the period except in the fluted dropper with diagonally curved ribs.[34] The "Champion" drill of Johnson, Gere and Truman of Owego, New York and the "Buckeye" drill of Mast and Company of Springfield, Ohio were also widely distributed. In Indiana, first at Milton

[32] New York State Agricultural Society, *Transactions* (1855), 15:58; J. J. Thomas, *Farm Implements and Farm Machinery*, 152–154 (New York, 1869); *American Agriculturist*, 28:113 (March 1869); 46:357 (August 1887); Whitcombe, *The Canadian Farmer's Manual*, 556 (1874); *U. S. International Exhibition*, 1876, *Reports and Awards*, group 23, p. 7–11; *Farm Implement News* 7(10):29 (October 1886), and numerous references elsewhere in the agricultural press.

[33] *American Agriculturist*, 37:79, 231, 249 (February, June, July 1878); Allen, *Digest of Seeding Machines*, 738, 766; *U. S. International Exhibition* as given above.

[34] Allen, *Digest of Seeding Machines*, 617, 662, 739, 766. A similar feed patented in 1862 was that of Samuel Keeler and Jacob Barthel. *Ibid.*, 34, 142. Mast and Gardiner patented a regulating gate for an internal force feed in 1878. The gate moved laterally into the wheel to regulate the amount sown. U. S. Patent No. 208,834.

and later at Richmond, was the organization which came to be the Hoosier Drill Company. It was based originally upon the inventions of Joseph Ingels, particularly a rotating narrow feed-wheel with corrugated edges and later, in part, upon the fluted feed of J. M. Westcott (referred to above) who became prominent in the affairs of the company.[35] The Empire Drill Company of Shortsville, New York continued to be a factor in the drill business all through the latter half of the century.

The stage of development of grain drills in America is recorded in the account by John Coleman, British juror and chairman of the section on agricultural machinery at the Centennial Exposition in 1876. Numerous drills were shown, all from the United States, and these were thoroughly tested.

> One of the great modern improvements which is now generally adopted is some kind of appliance to secure a force-feed. There are various ways in which this is secured. The most common is to have a roller on the shaft, either fixed or shifting, which, working in a confined position (the seed-cup), carries a certain quantity of grain round with it for each revolution, and the seed falls away from it into the tubes which conduct it to the ground. These rollers are various as to form and surface corrugations; but the great point of difference as to results depends upon whether the roller fills the seed-cup or only occupies a varying portion according to the quantity of seed to be sown. . . . Then, again, the quantity of seed to be sown is regulated in two ways, either by change-wheels, causing the seed-spindle to revolve faster or slower, or by opening or closing a slide door in the seed-cups. . . . We may notice other salient points of recent improvement common to most of the machines that were exhibited. An arrangement by which the alternate hoes can be set forward seven or eight inches, and thus present a broken line, with more space for the passage of clods, stones, or weeds. This is not a requisite or desirable position when the soil is in a favorable condition, because the closer the hoes are the more will they act as harrows in breaking and pulverizing the surface. A combined leverage, by which raising the hoes out of the ground throws the drill out of gear, and this is such a quick action that not a grain need be wasted. The lower portion of the hoe-frame is hinged, so that in the event of coming in contact with a post, stone, or tree-root, a not unusual accident in many districts, the hoe flies back and accident is avoided. As soon as the obstruction is removed, or rather the machine is set free from the obstruction, the hoe, acted upon by a powerful rubber spring, flies back into its place. This is a very perfect and ingenious arrangement. Then either in front of or behind the seed-box is

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[35] *American Agriculturist*, 38:298 (August 1879); *Prairie Farmer*, 50:247 (1879); 51:93 (1880); notes of W. H. Bates. The Empire drill of 1887 is illustrated in *American Agriculturist*, 46:136 (March 1887). For the Hagerstown drill, see *ibid.*, 38:277 (July 1879).

placed a small seed-distributer, driven from the main wheel by a crank. With this the grass-seeds, clover, and timothy can be sown at the same time as the grain. The hoes are fixed, and cannot be varied so as to drill the corn at varying widths. This must be considered a disadvantage, and it would be desirable if it could be overcome. We must also notice, as a useful appendix to most of the better machines, a small apparatus for indicating the area traversed during work. This is known as the 'Surveyor,' and comprises a thread on the seed-spindle, actuating a small-toothed wheel, which drives an indicator on a dial-plate. Without pretending to absolute accuracy, this arrangement gives a close approximation. . . . For planting pulse crops, the seed-cups that are not required to sow may be closed up. On the whole, we are led to believe that great progress has been made in the manufacture of grain-drills, and that American makers are decidedly ahead in this respect.[36]

Let us again pick up the European thread. The interest in drills increased slowly in Great Britain from the beginning of the nineteenth century, but they were so scarce that travelling drills went from Suffolk as far as Oxfordshire for many years before 1840 to serve those scattered farmers who desired their use. At the exhibition of the Royal Agricultural Society at Derby in 1843, sixty-one drills, pressers, and seed-sowing barrows, as well as four dibblers were exhibited. Drilling, dibbling, and broadcast sowing were all in general practice about 1850. Except in root culture, in which drilling was firmly established, broadcasting was the most common mode of seeding, especially in Scotland, but it was predicted that drilling would come to be the dominant method used. Drilling had spread most widely in the southern part of England where it was said in 1851 that "The sower with his seed-lip has almost vanished from southern England, driven out by a complicated machine, the drill, depositing the seed in rows, and drawn by several horses." Although considerable horse labor was required in drilling, it saved much more by eliminating repeated dragging and harrowing. In fact, it was estimated that the saving amounted to half. However, Morton's *Cyclopedia of Agriculture*, speaking of the whole of England in 1851 said, "Drilling corn is as yet far less

[36] *U. S. International Exhibition*, 1876, *Reports and Awards*, group 23, p. 7–9. Coleman reported that fertilizer distributors were supplied by several firms but he did not consider them of much value. That of Bickford and Huffman was pronounced the best by him.

common than broadcast sowing, but it is steadily progressing in every district of England where high farming and improved cultivation prevail."[37]

Professor Low, writing in *The Rural Cyclopedia* in 1852, gave the following résumé of the principles then in use in drill construction in England:

> A frame-work is placed upon two wheels; and upon this is an oblong box for containing seeds. From the axle of the wheels motion is communicated to a spindle or axle, which passes horizontally through the lower part of the box; and upon this axle may be fixed, at the distances required, a series of grooved or fluted cylinders. There are apertures formed near the bottom of the box, and as each cylinder revolves amongst the seeds, a certain portion of them is collected in the grooves at each revolution, and is carried round in the grooves and falls through these apertures. By making the grooves larger or smaller, so as to contain a larger or smaller quantity of seeds, or by making the apertures of the seed-box larger or smaller, so as to allow a larger or smaller quantity of seeds to pass through, the machine can be made to sow the seeds more or less thick, as may be required. The seeds, after passing through the apertures, fall into tubes or funnels, through which they are conveyed to the ground. Immediately before the lower part of each funnel is a sharp coulter of iron, which encloses the lower part of the tube, and makes a rut in the ground into which the seeds fall. By these means they are sown in the quantity required and at the depth to which we choose to set the coulters. To allow the rows to be at larger or smaller intervals, the cylinders are generally moveable upon the spindle, so as that they may be set at any distance required, as 9, 10, 12, or more inches. The coulters are made to move at the depth required, and to be lifted up along with the tubes or funnels when necessary, as at the turning at the end of the ridges, the encountering of obstacles, and the like. Sometimes the axle, instead of having cylinders upon it with grooves, has a series of small pinions or teeth. Or, in place of the teeth, there is employed a series of stiff brushes. The teeth or brushes revolve in the same manner as the fluted cylinders, and, by keeping the seeds in motion, cause them to fall through the little apertures or holes near the bottom of the box.

Other evidence indicates, however, that the cup feed, particularly the form in which the cups project from disks turning through the seeds, was one of the leading methods of dropping. Morton says that the cup feed "is adopted in what are called

[37] Henry Colman, *European Agriculture and Rural Economy*, 1:151 (Boston, 1846); 2:221 (Boston, 1848); Morton, *A Cyclopedia of Agriculture*, 1:714–715, 717–719 (Glasgow, 1851); Royal Agricultural Society of England, *Journal* 1:8 (1840); 4:456 (1843); 12:335, 600–601 (1851). The latter raised the question whether it is best to buy one complicated general purpose drill or two separate machines for wheat and turnips.

Suffolk drills: and, generally described, it acts by cups attached to the projecting arms on a revolving disk, which cups dipping into the seed, lift successive portions, each of which, falling from them as they attain the height of their revolution, is received into a funnel properly placed for its removal to the ground."[38]

An American observer at the London Exhibition in 1851 commented upon the many "perfect" grain drills shown there but added that they were "yet too complicated and expensive for introduction into this country. They do not possess any material advantages over our own drills, which are afforded at one-third the price of the best English drill." Of these the best known type was the Suffolk drill, described in 1852 as

> a highly improved modification of Cooke's, together with additional apparatus and more extensive adaptations; and it comprises many subvarieties, and is familiar, in some one or more of these, to a large proportion of all the better class of English agriculturists. . . . 'The Suffolk drill,' says Mr. Ransome, 'is now the kind in the most general use throughout the kingdom, and is adapted for drilling corn [i.e., small grain] either on level lands or on ridges, and on all descriptions of soil. It is furnished with independent levers, by which the coulters are each readily and separately made to avoid any rocks or irregularities of the ground, and a press-bar, extending over the entire width of the machine, to force the coulters, in case of need, into hard ground, with a varying degree of pressure, according to the texture of the soil. The coulters can be set so as to drill the corn at any width, from four inches to a greater distance; they also, if required, readily allow of the introduction of the horse-hoe; and, from being placed in double rows, they admit, when at work, large stones to pass between them of a size that, under the old plan of placing the coulters in one line, would break or stop the machine. The most complete drills are furnished with the "swing steerage". . . by which the drill-man keeps the rows at exact or even distances from those which have been previously drilled. The "corn barrel" is made to deliver from two pecks to six or seven bushels . . . of seed per acre.'

The use of fore-steerage distinguished the general appearance of many English drills from those in use in America. The device was adopted after the addition of the fertilizer and mechanism for distributing it had increased the weight of the drill so much that it added materially to the work of the carter in steering the drill. In America, where lighter drills were the rule and

[38] Wilson, *Rural Cyclopedia*, 4:281. Morton, *Cyclopedia of Agriculture*, 2:887–889, 896, describes the different methods of dropping in use in England and indicates that the cup feed is regarded as the best.

where exactness in sowing was much less common, the problem of guiding a horse with one hand and steadying the shaft with the other was not appreciated.

Wilson, in describing the Garrett drill called it

> a highly improved variety of the Suffolk drill, together with additional contrivances for giving it both nicety of execution and a wide range of adaptation. . . . 'The ends of the drill boxes are made of iron instead of wood, allowing the travelling wheels to run half the distance from the outside coulters at which the others are set, and so returning in the same wheel-marks that they made in going the contrary way of the field, to leave the rows all the same distance apart.'

He describes as one of the improvements of this drill the device consisting of different sized cogs to drive the dropper shaft at different speeds when going up or down hill in order to insure an even distribution of seeds. The drill had cup and brush feeds and fore-steerage. One feature of the Suffolk drill which these writers seem to take for granted is the peculiar short, shoe-shaped furrow opener, known as the Suffolk coulter.[39]

The Cooke drill persisted as a type throughout this period. In 1852 it was described as follows:

> 'The seed-box is of a peculiar shape, the hinder part extending lower than the fore part. It is divided by partitions, and supported by adjustable bearings so as to preserve a regular delivery of the seed whilst the machine is passing over uneven ground. The feeding cylinder is made to revolve by a toothed-wheel, which is fixed on each end of the main axle, and gears with other toothed wheels on each end of the cylinder; the surface of the cylinder is furnished with a series of cups which revolve with it, and are of various sizes, according to the different seeds intended to be sown. These deposit the seed regularly in funnels, the lower ends of which lead immediately behind the coulters. . . . The seed, as it is deposited, is covered in by a harrow fixed behind. The carriage wheels are larger in size than usual, by which means the machine is more easily drawn over uneven ground; and the labour of working is reduced.'[40]

Certain other English drills of the period deserve mention. The Bedfordshire drill invented by Salmon had won distinction

[39] New York State Agricultural Society, *Transactions* (1851), 11: Appendix, p. 103; Wilson, *Rural Cyclopedia*, 4:282–283; Morton, *Cyclopedia of Agriculture*, 2:886, pl. 48; Royal Agricultural Society of England, *Journal*, 12:602 (1851); *Catalogue of the London Exhibition*, 1851, 1:375, 385; Colman, *European Agriculture and Rural Economy*, 2:225–226.

[40] Wilson, *Rural Cyclopedia*, 281–282.

as early as 1817 and continued its popularity for sowing grain but not for distributing fertilizer. It had a cup feed, shoe furrow-openers, fore-steerage, and a device by which it was claimed the seed-box was kept level and the rate of sowing uniform. Richard Hornsby and Son were prominent manufacturers of excellent drills with Suffolk coulters, cup feed, and India-rubber seed pipes invented by Hornsby in 1850.[41]

By the sixties the type of drill used in England had not changed much, but new manufacturers were coming into prominence. Of the four leading drill manufacturers, Garrett, Hornsby, Smyth, and Wedlake, only the latter failed to exhibit at London in 1862. The Suffolk coulter was almost universal, steerage was common, and telescoping metal seed pipes were the rule (with Hornsby using rubber).[42]

English drill manufacturers naïvely decided not to exhibit at Philadelphia in 1876 because they felt that they had nothing to learn and thought it best not to expose their machines to the sharp eyes of American inventors; and they considered that since they could not hope to successfully invade the American market they had little to gain. However, it was not long before they began to feel the effects of American competition. At the

[41] For the Bedfordshire drill, see *ibid.*, 284–285; Royal Agricultural Society of England, *Journal*, 12:604 (1851). For Hornsby's drill, see the *Catalogue of the London Exhibition*, 1851, 1:395; Morton, *Cyclopedia of Agriculture*, 2:890, 896–897, 901; Royal Agricultural Society of England, *Journal*, 12:602–603 (1851); 18:431 (1857); British Patent No. 13,165. A type of drill known as the drop drill, which deposited the seed and fertilizer in heaps separately at intervals in such a manner as to economize on fertilizer and prevent the burning of the seed, was manufactured by Ransome and by Garrett. Wilson, *Rural Cyclopedia*, 285. A water drop drill was manufactured by Garrett. Royal Agricultural Society of England, *Journal*, 17:577 (1856). A large number of drills are illustrated and described by Morton, *Cyclopedia of Agriculture*, 891–906.

[42] *The Illustrated Catalogue of the Industrial Department, British Division, International Exhibition, London*, 1862, 1 (Class 9): 18–98 (London, 1862); Paris Exposition Universelle, 1867, *Rapports du Jury International*, 12:67–69 (Paris, 1868); J[ohn] Donaldson, *British Agriculture*, 205 (London, 1860). Eugene Tisserand, writing of the grain drill exhibit at Wien in 1873, called the American machines imitations of the English drills and thought they had no chance of meeting European competition. *Reports of the Commissioners of the United States to the International Exhibition . . . Vienna*, 1873, 1:302 (Washington, 1876).

Centennial Exhibition, the Americans followed the English innovation at the Bedford trial of 1874 of testing the drills for accuracy of drop, but they made the test much more thorough by

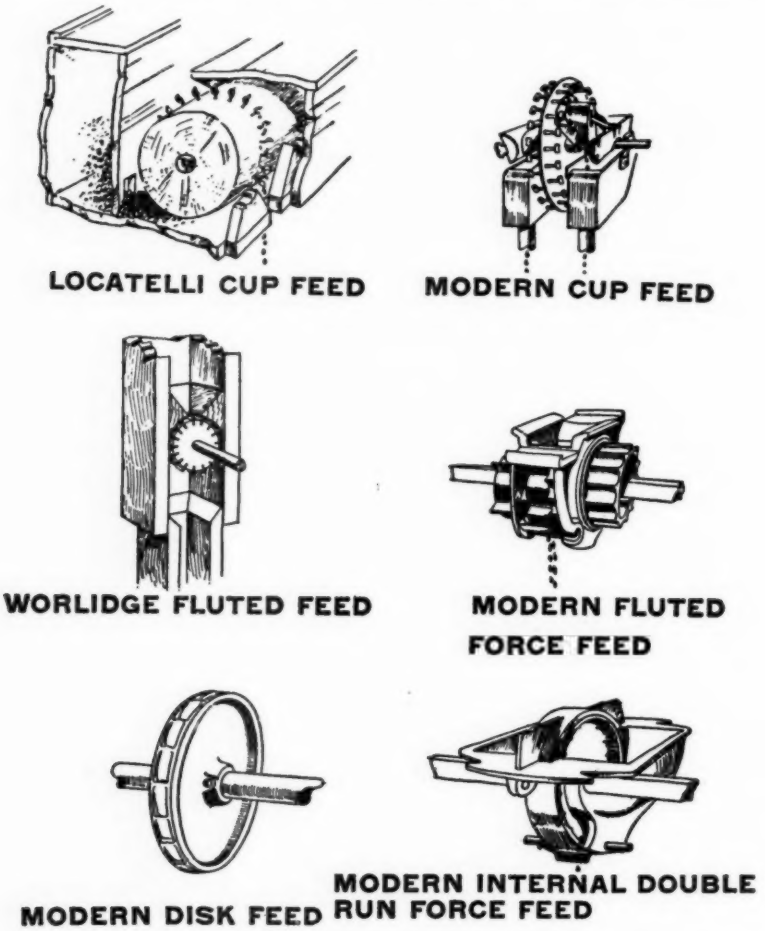

FIG. 10. Types of seed droppers used in grain drills

varying the position of the machines. It was found that the variation even among the poorer of the American drills was much less than among the best English drills at Bedford. "This I attribute," said J. Coleman of England, "to the presence in all

the American drills of some kind of force-feed, a most important and valuable arrangement, and which completely supersedes the revolving barrel with discs and seed-cups which is still retained in the majority of English drills."[43] Due, no doubt, to the publicity given the trials at Philadelphia in 1876 and the success of the Americans at Paris in 1878, the British found themselves compelled to make some changes. An English writer in 1881 stated that English implement manufacturers had succeeded, in spite of high tariffs, in securing a large share of the European trade but added that if "the competition which is so keen from our Transatlantic friends [is] successfully met" England must have the best implement. While the trend of English drill construction continued, in general, along the lines then in vogue, James Coultas did introduce an "American type" drill in 1881. It was said that the drill "is constructed upon the lines of the American force-feed drills, which, varying in detail, are identical in principle, and are a wide departure from the disc and seed-cup with which we have hitherto been contented. Mr. Coultas was led to adopt this arrangement, because he found that he could not sell the English drill to foreign customers." This latter point may have been an exaggeration but it indicates a growing recognition of the worth of American drills.[44]

In France the use of the grain drill lagged behind that across the Channel. The French scholar, Duhamel du Monceau, wrote six volumes on the new husbandry with its drill culture. He and Chateauvieux and others had produced drills, and the interest in the subject among the farmers and others seemed to be great, yet little was accomplished. It was not until 1831 that there was any extensive move to improve the tillage in France by the use of drill culture. A grain drill, much like that of Chateauvieux, had been

[43] Royal Agricultural Society of England, *Journal* (ser. 2), 10:629 (1874), for the Bedford trial where all but two of the drills had cup feed; (ser. 2) 13:1, 40 (1877), for Coleman; (ser. 2), 17:602-603 (1881).

[44] *Ibid.* (ser. 2), 17:602, 617 (1881). The bulk of the imports of agricultural machinery into South America came from England before 1876. A British observer at the Centennial thought that the British made a mistake in not exhibiting there and feared that the South American business might go to the United States. *Ibid.* (ser. 2), 13:2 (1877).

invented by Hugues, and a joint-stock company was organized to manufacture and sell this drill which, it was said, would save much in seed and in the expense of cultivation and result in an increase of one fifth in yield. Many of the notables of the time were shareholders in the company which had a measure of success for a few years. The enthusiasm aroused between 1831 and 1837 for drilling soon died down and the farmers returned to their old method of sowing by hand. Some trace of the use of drills continued and extended a little in northern France, but it was not until the Crimean war in 1854–1856 that there was a marked movement toward drilling. The drills most favored were those of Jacquet-Robillard and the English implements, particularly that of James Smyth and Sons of England. From that time English drills were relatively prominent in France. However, in 1889 the general use of seeding in rows was not widely accepted except by a very limited number of farmers. Just as the more rapid introduction of grain drills in England as compared with France was attributed to the greater use of root forage crops among the English and consequently a greater familiarity with row culture, so the spread of drilling was greatest in those sections of France where sugar beets were grown.[45]

At the Paris Exposition of 1867, a number of the drills exhibited, notably those from England and France, gave evidence of progress in this phase of agriculture. The French admitted that most of their drills were inferior to those of the English manufacturers, Smyth and Garrett, but they pleaded that French drills were made to meet particular conditions and also the depleted purses of the French farmers. The most prominent of the French drills was that of Jacquet-Robillard. It had a distributor with blades or agitators with paddles, which turned rapidly in the seed and pushed it through adjustable openings in the side of the seed-box The coulters were described as weak. Some of the French manufacturers followed the English pattern of independent movable coulters. Among these were Gautreau and Leclère,

[45] Paris, Exposition Universelle Internationale de 1889 à Paris, Grandvoinnet, *Rapports du Jury International*, group 6:362–363; Paris, Exposition Universelle, 1867, *Rapports du Jury International*, 8:179, 181 (Paris, 1868).

whose drills sold all over France. The Count of Montenol exhibited a drill with a cup feed, independent movable coulters, and rear steerage. Hugues, Dombasle, Grignon, and others exhibited cup-feed drills.[46]

At the Wien exhibition in 1873, the English implements or those modeled from them were the leaders, although Austria-Hungary looked to American manufacturers for agricultural machinery. An Austrian writer, describing the implements exhibited, said, "in the manufacture of agricultural machines, England is the first among the European nations. . . . No feeling of admiration touched our souls as we passed through the Machine Halls of Germany, Austria, and Hungary." Some crude drills from Russia and Poland, much like those of the days of Tull in England, were shown, and also some Hungarian and German machines. The low state of drill manufacture in much of Europe paralleled a backwardness in drill culture itself. The peasants of Hungary farmed with crude implements and sowed their grain broadcast but some of the large farmers, especially certain nobles, used English drills and their peasant neighbors followed their example. In Moravia, Bohemia, and Austrian Silesia, there was greater agricultural prosperity than in Hungary, and English drills and other implements were coming into use. Agriculture in the southern provinces of Russia was very backward, and further disturbed by the change from serfdom to free labor; drills were quite unknown as was also the case in the Turkish Empire. Among the much distressed Poles, agriculture was described as "barbarous", and drills were used only by the large landed proprietors. In Norway, Sweden, and Denmark, grain was sown broadcast, except on the large estates, and even in Flanders everything was sown broadcast, and the language was said not to have a word for "drill."[47]

In 1878 the Americans, perhaps encouraged by their own showing at Philadelphia, entered the competition at Paris against the

[46] *Ibid.*, 8:179, 181; 12:67–71.

[47] Royal Agricultural Society of England, *Journal*, 21:294 (1860); (ser. 2), 5:159,163–165, 170, 198, 204, 207 (1869); (ser. 2), 6:20 (1870); (ser. 2), 10:62–63, 70, 326, 327, 347, 364, 367, 375, 380 (1874).

Europeans. A quotation from the report of the American commissioner will serve to summarize the progress in drill manufacture to that date.

> The American drill is quite a different affair from the English or French implement for the same purpose, and is but little known in Europe. Its comparative simplicity and lightness, with equal if not superior efficiency, made it an object of great attention both at Philadelphia in 1876 and at Paris in 1878. . . .
>
> The best American drills have systems of 'force-feed' instead of depending upon revolving cups or merely upon the gravity of the grain, which is variable as the hopper becomes gradually emptied. All the English drills, and most of the French, have a complicated system of short sheet-metal conductors which lead the grain to the shovels; the American drills employ a caoutchouc tubular conductor. . . .
>
> One very distinct point of difference between the European grain-drills and the American is found in the shovels and the mode of forcing them into the soil, so as to make furrows for the seed which drops behind them. The European shovels, for the English and French agree in this, are nearly vertical, trailing a little backward in fact, and are forced into the soil by means of a weighted lever of the second order attached to each. One or more cast-iron weights are placed on the end of the lever, according to the hardness of the ground, and the result is no small addition to the weight of the machine, needless were the shovels made 'hooking' (so called), so as to draw into the soil, the point ranging forward in the manner of the ordinary plow, which keeps itself in the ground by virtue of the mode of presentation of its point . . . . the backward inclination of the shovels . . . is designed to prevent the catching and trailing of weeds. . . .
>
> A large number of grain-drills were exhibited from England and France, also some from Sweden and other parts of the Continent outside of France. The Gautreau drill . . . may be taken as fairly representative, and a comparison of it with the "Farmers' Friend" . . . will illustrate the principal differences between the approved machines on the respective sides of the Atlantic.
>
> The Gautreau drill . . . has a fore carriage (*avant-train*), which is controlled by the workmen at the rear of the machine, and serves to guide the drill. . . . In the English drills this duty is frequently allotted to a man in advance of the hopper-box, walking between it and the fore carriage. . . .
>
> The man grasps an extension-bar extending laterally from the upper member of the fore carriage, and the latter is rotated on its vertical pivot by the horizontal movement of the bar, so as to deflect the course of the carriage to the right or left. Thus the man is able to keep the course perfectly straight. Great care is exercised in this respect, as a horse-hoe is expected to follow in due time to cultivate between the rows of plants. . . .
>
> In the Gautreau drill each shovel of the gang is independent and their distance apart may be varied within certain limits. The whole gang is lifted out of the ground by a single motion, or lowered into working position, by means of handles; in some cases the shovels being in two gangs, half on each side, so that one-half may be lifted out of work in finishing up a narrow land or on the edge of a field. Plowing in narrow lands is much more common in Europe than with us, as excess

of rain is there more frequent. . . . The seed passing down the conductor is dropped in the furrow at the rear of the shovel, and is covered by means of the two prongs which trail at the rear.

The distributor in the hopper is worked by gearing from the ground-wheels and is thrown into or out of action by a pinion of engagement worked by a handle. . . .

The 'Farmer's Friend' drill, . . . to which the only gold medal for grain-drills was awarded in Paris, is selected to illustrate some of the points of difference between the American and European drills. It has several features not found in the English and French sections:

Cone-gearing or analogous device for regulating the quantity sown per acre; shiftable during the motion of the team and operated without loose parts.

Force-feed for positively removing seed from the hopper in regulated quantity and dropping it into the conductor.

A *rear-shifter* for throwing the shovels into one or two gangs, the latter known as 'zigzagging the hoes.'

Another American device is the *spring-shovel*, which yields to obstructions and flies back into place when the obstruction is passed. A substitute device, also American it is believed, is the *break-pin* on the hoe, which allows it to rotate rearwardly and pass an obstruction, the hoe being then reset and a new pin placed. The object is to confine the breakage to a mere wooden pin, which is easily replaced from a supply carried in the box.

The last-mentioned features are of course more particularly useful in new ground and in soils infested with large stones or roots.

The simultaneous throwing of all the shovels into or out of action, the fertilizer and grass-seed attachments, and the 'surveyor' for indicating the area of ground passed over are found in grain-drills on both sides of the Atlantic. . . .

In no respect is the difference between the American and the European grain-drills more marked than in the matter of the feed.

Force-feeds of various kinds are found in all the best American drills, and the European almost all follow the design of the old Spanish *noria* [i.e., the cup feed as used by Locatelli]. . . .

A noticeable feature of variation in the European and American methods is in the apparatus for changing the feed or quantity of seed sown. This, in Gautreau's French drill, consists of a cog-wheel on the axle, one on the axis of the seed-wheels and a shiftable connection between the two. . . .

It may be mentioned also that the Gautreau drill, like many others made in France and England, has seed-boxes articulated to the axles [as was the case in the drill of de la Levrie] so as to be capable of inclination forward or backward in ascending or descending hills, or made vertical on the level. This is presumably to insure proper action of the feed-cups, and is unnecessary with the force-feed American drills.[48]

Although the grain drill has been steadily improved with increasing accuracy and larger units during the last fifty years,

[48] *Reports of the United States Commissioners to the Paris Universal Exposition*, 1878, 5:102–108 (Washington, 1880).

it has undergone no fundamental changes, except in the furrow-opener and, in a tentative way, in the new type of dropper now being introduced in England. The hoe furrow-opener in America and the Suffolk coulter in Europe dominated the field in the

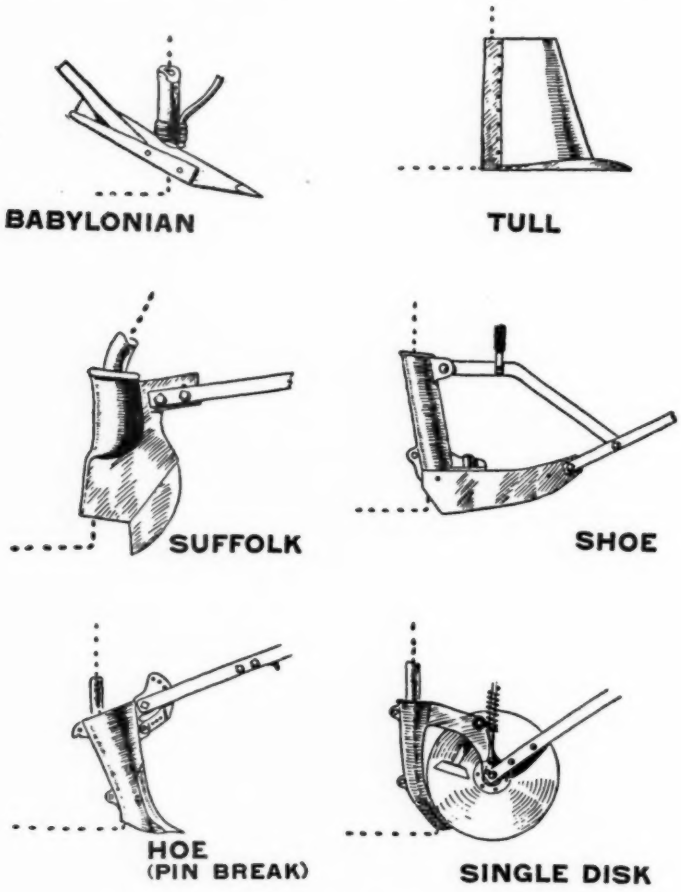

FIG. 11. Types of grain-drill furrow openers

nineteenth century, and they are still in common use today. Another type, used to a limited extent, was the shoe furrow-opener. This type of shoe is common in the corn planter and was used to overcome troubles with trash, as was the Suffolk coulter.

It was popular both in the United States and in Europe but did not become the dominant type, especially in America.[49]

Today the drill trade, particularly in America, is strongly dominated by the disk furrow-opener. This device seems to have originated in the crude disk plow patented on August 7, 1847 by G. Page. On June 27, 1854, a patent was issued to H. M. Johnson for the arrangement of disks in a gang. In 1859, S. G. Randall patented a grain drill consisting of two sets of flat disks set in two gangs like our present-day disk harrows, with seed-boxes from which tubes descended to conduct the seed to the ground.[50] In 1886 the Corbin disk seeder consisted of a disk harrow, built to throw the dirt in rather than out, and a broadcast seeder-box built with an apron directing the seed in front of the disks. The Canton disk harrow with seeder attachment was similar except that the disks threw the dirt out. The Colorado seeder, described as being in successful use in 1887, was a single-disk implement in which the seed was fed to the back of the disks.[51] By 1891 there was a drill on the market with a broadcast seeder-box on the customary two-wheel frame with a disk harrow directly beneath throwing the dirt outward.[52] Another step was taken in 1893 when George W. Packer patented a drill with a seed-box above each side of a disk harrow and with three force-feed units and branching seed-pipes for each box.[53] The same year the Havana disk press drill, previously built as a shoe drill, fed the seed to the furrow behind the disks,[54] and the Hapgood Plow Company advertised a peculiar drill with a set of disks on one shaft set at an angle to the line of draft like our present-day one-way or wheatland plows. It had three wheels which also carried the broadcast seeder.[55] In 1895 the Fuller-Lee Company advertised a drill

[49] *Farm Implement News*, 7 (9):30–31 (September 1886); 8(3):8–9 (March 1887).

[50] *Ibid.*, November 1885, p. 5; Allen, *Digest of Seeding Machines*, 23, 139.

[51] *Farm Implement News*, 7 (1):6 (January 1886); 7 (4):19 (April 1886); 8 (6):23 (June 1887).

[52] *Ibid.*, 12 (8):78 (August 1891).

[53] *Ibid.*, 14 (16):24 (Apr. 20, 1893); Patent No. 495,120.

[54] *Ibid.*, 14 (35):26 (Aug. 31, 1893). The press drill was not new at this time however. In 1884 it was said that "This method of seeding has many enthusiastic advocates." *Ibid.*, 5 (2): 11 (Aug. 30, 1884).

[55] *Ibid.*, 14 (51):32 (Dec. 21, 1893).

consisting of eight disks in pairs, each pair on a separate journal, that had been in the field for five years.[56] By 1896 the Superior Drill Company was advertising both single- and double-disk furrow openers, and the principal types of the disk drill were on the market.[57] Recent years have seen developments of no small consequence, but they have been improvements on existing types, and, except in the case of the Hornsby-Leake drill mentioned below, refinements in detail, and adaptations to power farming with its large-scale operations.

Today, foreign practice in drill construction differs somewhat from that in America, particularly in the dropping mechanism. The most common feed on English drills is still the cup type. The seed-box is divided into compartments to insure uniform sowing on uneven land. Each seed compartment has a disk with cups on each side to pick up the seed and deposit it in hoppers which may be tilted back to throw any spout out of action. The seed-barrel, consisting of a shaft and disks, is reversible. The larger cups sow large seed such as beans and oats on one side and smaller seed on the other. A second barrel serves to sow root and clover seed. In the Pilter drill the adjustment for large and small seed or to increase the quantity sown is made by causing the seed cups to project varying distances from the side of the disks. The cup type of feed and the adjustable form are also in common use on the Continent.

Another type, common on the Continent and used in England on some clover drills, is the disk feed in which the seed is picked up by pockets in the side or circumference of the disk. This type takes several forms. The internal and external force feeds are used in Europe but are not as well known as in the United States. The agitator type of seed distributor in which the seed is pushed toward the seed-box opening by means of a wheel or a brush is somewhat more commonly used in Europe.

A new type of drill known as the Hornsby-Leake Precision Drill, invented by Professor Engledow of Cambridge, has recently been introduced in England. The sowing unit, of which

[56] *Ibid.*, 16 (36):37 (Sept. 5, 1895).
[57] *Ibid.*, 17 (50):33 (Dec. 10, 1896); 17(51):65 (Dec. 17, 1896).

there is one for each two furrows, consists of a cylindrical seed container mounted behind a sloping hopper. In the lower portion of this container there is a vertical cone which rotates slowly with a vibrating motion, imparted by a ratchet-like device, which gives the seed a constant shuddering action and expels a regular number of seeds, controlled by steps on a baffle above. The dropping mechanism of this drill is unlike any other ever devised. It is claimed that the use of this new principle results in greater regularity of sowing and in an appreciable increase in yield as compared to other types of seeders.

All of the furrow openers found in the United States are used in Europe although the emphasis is different. While disk openers are more common in the United States, the hoe or shoe coulters, particularly the modification of the latter known as the Suffolk coulter, are more frequently found abroad. Whereas American drills are what are known as pole drills, the European machines are often provided with fore-carriage steerage which gives greater evenness but increases the cost of construction and operation.[58]

This discussion may well include a résumé of the improvements that have been made in American drills during the past twenty years. The matter of improvement is of importance, not only from the standpoint of greater efficiency, but also, in view of the agricultural situation, in enabling us to form a sound judgment on the mooted question of current farm-machinery prices. The wheat of today may be indistinguishable from that of twenty years ago, but the drill which sows it is quite a different implement from that of the earlier day, quite apart from the obvious changes in external appearance. The improvements have increased materially the durability of the drill, improved its capacity and operating efficiency, and decreased the losses due to wear and breakage and the resultant expense and loss of time. As

[58] A description of German drill practice can be found in Ing. Vormfelde, "Landmaschinen," in F. Aereboe, J. Hansen, and Th. Roemer, *Handbuch der Landwirtschaft*, 3:99 ff. (Berlin, 1930); and Kühne, *Handbuch der Landmaschinentechnik*, 1:267 ff. J. R. Bond, *Farm Implements and Machinery*, 103–119 (London, 1923), gives a good account of British machines. A description of the Hornsby-Leake drill is to be found in the advertising matter of Ransomes, Sims, and Jeffries, Ltd.

compared with the drill of 1910–14, a committee of distinguished agricultural engineers has estimated that the drill of 1932 was a 40 percent improvement.

A number of improvements may be cited as examples. In 1923 grease cups were substituted for oil holes in disk bearings; in 1928 grease-gun lubrication was added; and late in 1935 a drill with all the gears running in oil was introduced. The plain axle bearings have been replaced by roller bearings with a self-aligning box. Likewise the simple taper chilled disk bearing, open at both ends, has been replaced by a bearing sealed to exclude the destructive dust. The new all-steel hopper of rust-resisting steel has

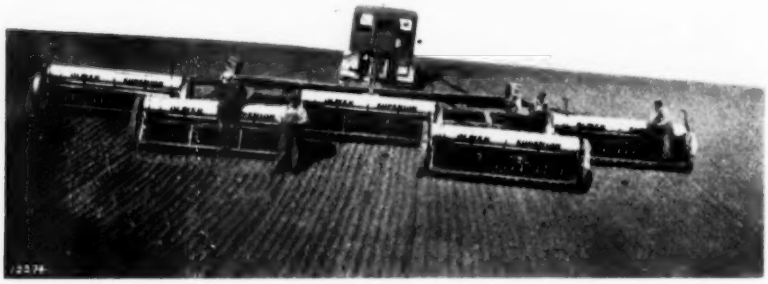

FIG. 12. A tractor-drawn battery of grain drills in the Far Northwest

taken the place of the wooden hopper with cast heads, an assembly which was subject to rotting, warping, and cracking, and tended to throw the feeding mechanism out of adjusment. The inverted V-shaped frames made of riveted angle steel are much more rigid than the former bolted frames of flat steel rails and braces. These and other similar improvements have resulted in easier operation, lighter draft, longer life, and generally improved efficiency.[59]

[59] American Society of Agricultural Engineers, *Report of an Inquiry into Changes in Quality Values of Farm Machines Between 1910–14 and 1932*, 12 (St. Joseph, Mich., 1933).

Thus the grain drill, begun so long ago, required some thirty-six hundred years to reach the point where its real test and development took place. During that time no single element was added to the device used by the Babylonians. For the most part, agriculture was primitive during these centuries and was, generally speaking, on a local subsistence basis. The pressure for improvement came almost entirely from a desire to raise the subsistence level rather than from the need of increasing the commercial surplus. Furthermore, the state of the mechanical arts conditioned what might reasonably be attempted. Certainly the confusion which existed in Western Europe during the Middle Ages was not favorable to rapid mechanical advance.

Perhaps it is more than a coincidence that the period of trial of the grain drill, the two hundred and fifty years following the invention of Cavalini's drill, coincided very closely with the remarkable activity which was ushered in by the geographical discoveries of the fifteenth century. The new spirit which pervaded Western Europe manifested itself in an intellectual and religious reorientation, a commercial revolution of great moment, and an industrial revolution, which was accompanied in some sections by an agricultural renaissance. As a part of this new movement in thought, trade, and technology, there was a development of the grain drill to the point where it was conceded to be practical and was coming into use both in Europe and America. The last century, with its rapid progress in the mechanical arts, has been a time of perfection and widespread use of this very practical agricultural implement which has been an important factor in bringing commercial cereal production to its present position.

RUSSELL H. ANDERSON

Museum of Science and Industry
Chicago, Illinois

NEWS NOTES AND COMMENTS

UNIVERSITY OF WISCONSIN HALL OF FAME FOR AGRICULTURISTS

In referring to the recognition accorded unusual achievement in agriculture by the University of Wisconsin, Mr. Clifford V. Gregory, in his article on "The Master Farmer Movement" in *Agricultural History*, 10:47–58 (April 1936), said: " . . . for the most part the men so recognized were scientists or agricultural research men. Few have been included whose efforts were strictly limited to farming."

By way of correction and elucidation, Mr. Chris L. Christensen, dean and director of the University of Wisconsin College of Agriculture, has supplied the following information:

"Since the creation in 1909 of the honorary recognition movement, the University of Wisconsin has honored in all 99 men and 15 women. Of the men 77 have been farmers, six were editors (several of whom have owned and operated farms), one was a milk distributor, two were lawyers interested in the development of productive cut-over acres, one was a cheesemaker, one was the director of a national breed association, one the founder and organizer of the Grange, two were inventors of the Marsh harvester, one was the inventor of the pea viner, one was a business executive directly related to farming, one was a country banker, one was the director of a state horticultural society, one was the manager of a large farmer cooperative and but three engaged in education or research. Of the fifteen women ten were homemakers and five were engaged in education.

"In creating this unique movement the faculty of the College of Agriculture of the University of Wisconsin expressly planned that academic learning would play absolutely no part in the selection of the men honored. The weatherbeaten farmer whose entire education might consist of but two or three winters at the district school, but whose native intelligence, perseverance, and qualities of leadership have forced him to a place in the front rank of agriculturists was to be singled out for recognition.

" 'This custom is altogether an effort to recognize those who because of their services to agriculture are deemed most worthy,' said one of the originators of the movement. 'It is a form of appreciation of the practical men of brains, energy, and achievement who year in and year out reside on our farms as well as those who serve in other fields of agriculture. In placing its stamp of approval upon the work of such men and women, the College of Agriculture not only recognizes the efforts of some of the worthiest men and women, but adds a deeper meaning and a new dignity to the agricultural industry.' "

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